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**Factors Affecting Implementation Success of CAD and CAM
Additions to CAD/CAM Systems: Operating Level Personnel's Perspective**

by

Andrew Collin, B.Comm, Honours

**A thesis submitted to the Faculty of Graduates Studies and Research
in partial fulfilment of the requirements for the degree of Master of Management Studies**

School of Business

Carleton University

Ottawa, Ontario

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Additions to CAD/CAM Systems: Operating Level Personnel's Perspective

submitted by Andrew Collin, B.Comm. Honours
in partial fulfilment of the requirements for
the degree of Master of Management Studies

Thesis Supervisor

Director, School of Business

Carleton University

Date

This thesis is dedicated to my mom who died on Tuesday, March 29, 1994.

I miss you and love you always.

ABSTRACT

This research was initiated after a literature review revealed that the potential benefits of CAD/CAM were not being reaped by North American manufacturers, largely as a result of insufficient attention being paid to implementation. CAD and CAM operators were identified as influential stakeholders in this process. This thesis thus aimed to elucidate factors affecting their perceptions of CAD and CAM implementation success. Fifty-four CAD designers and CAM machine operators from nineteen Canadian high technology companies were queried as to the significance of nine independent variables. These were: the presence of an effective champion, operating level personnel participation, top management support, end user training, "lateral" support, and usefulness and user-friendliness of the equipment. Two characteristics of end users were also considered. The sample was quite homogeneous with most of the companies indicating that they had considerable experience with CAD/CAM.

Data analysis was pursued separately for designers and machine operators. This revealed that system usefulness and ease of use, training, and top management support contributed most significantly to operators' perceptions of implementation success, although the exact impact of these variables differed in the design and manufacturing environments. Hierarchical regression confirmed the importance of system characteristics to CAD designers. Organizational characteristics, including training, were more important to machine operators.

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1.0 INTRODUCTION

CAD/CAM is an increasingly popular concept for which a spectrum of definitions exist. For the sake of this thesis it is defined as a complex arrangement of sophisticated hardware and software which facilitates the creation, modification, and storage of design information and the electronic translation and transmission of this information to shop floor machinery to guide the manufacturing of components. This definition is derived from those of Adler and Helleloid (1987) and Gerwin et al. (1991). This definition includes the most universally accepted attribute of CAD/CAM which is its ability to electronically link design and manufacturing activities.

The potential benefits of CAD/CAM, and even CAD and CAM separately, are numerous and significant. These include reduced product development times, better quality products, and flexibility in product design and manufacturing (Adler and Helleloid, 1987). These benefits are made possible by the ability of these technologies to aid intra- and inter-functional communication as manifested by electronic design for manufacturability rules (for example Symon and Clegg, 1991).

Companies are not reaping all of the potential benefits of CAD/CAM (Beatty and Gordon, 1991). Adler (1989) concurs, stating that "relatively advanced segments of U.S. industry are still struggling to capitalize on CAD/CAM's potential" (p. 202). Bentley (1991) adds that "over the past decade many companies have invested in CAD/CAM systems. A recent KPMG Peat Marwick survey revealed, however, that as few as 10% have explored or realised its true potential" (p.356). Many researchers attribute this unfortunate state of affairs to organizational rather than technical causes (Symon and Clegg, 1991). After a three year study Beatty and Gordon (1992) concluded that many of these problems stemmed from insufficient

attention being paid to the implementation process. They state that "managers often believe that choosing or adopting a new technology is the most important task, and they neglect implementation" (p. 49). Tornatzky and Fleischer (1990) add that implementation is "often ignored by innovation planners" (p. 231). Leonard-Barton and Kraus (1985) agree, stating that "...they (company management) pour abundant resources into the purchase or development of the technology but very little into its implementation" (p. 103). They conclude that "mistakes or overlooked issues in an implementation plan" (p.108) contribute to resistance to innovations.

1.1 THE IMPLEMENTATION PROCESS

Researchers recognize the significance of the implementation stage and the difficulties of carrying out implementation successfully. Eason (1988) refers to it as the "acid test" and the period when initial enthusiasm is "washed away in the fear and resistance of those who were to use the system" (p. 157). These sentiments are echoed by Hage (1980). Tornatzky and Fleischer (1990) state it "is neither simple nor easily accomplished" (p.198). And Gerwin (1982) remarks that it is characterized by "novel problems" (p.112).

The various definitions of the implementation stage as put forth by different researchers are roughly congruent. Typically implementation is preceded by the recognition of a need and the decision to take action to address this need. In the case of advanced manufacturing technologies (AMTs) this may entail, for example, the identification of a performance gap, the decision to purchase new equipment which, hopefully, will narrow the gap, and the selection and actual purchase of the equipment. Tornatzky and Fleischer (1990) list activities which typically occur during implementation. These include site selection, site preparation, equipment

installation, and training.

Researchers agree that implementation ends when the innovation begins to be incorporated into the activities of the organization on a more regular basis. Tornatzky and Fleischer (1990) identify the end of the implementation stage as that point when the equipment "begins to do something useful" (p. 198). Hage (1980) argues that the implementation stage ends with the decision whether or not to incorporate the innovation into the organization. The terms "routinization" (Hage, 1980; Gerwin and Kolodny, 1992), "routine operation" (Clark, McLoughlin, Rose, and King, 1988), and "institutionalization" (Hage (1980) describing Milo's (1971) change model) are used to define the stage which follows implementation.

For the purpose of this thesis the implementation stage is defined as that period of time after the equipment has been purchased and before it begins to have a positive incremental impact upon the organization. Thus, the interval during which the organization proceeds up the learning curve to the point at which it was before the new technology was implemented is included in this definition.

1.2 END USERS AS A SOURCE OF RESISTANCE

The successful implementation of technological innovations, especially radical innovations, is commonly threatened by resistance from operating level personnel.¹ Leonard-Barton and Deschamps (1988) state:

¹ For the purpose of this thesis the terms "operating level personnel", "operator", "end user", and "user" are considered synonymous.

"Successful innovation implementation depends upon acceptance by organizational members targeted as end-users of the innovation. Individuals low in the organizational hierarchy can slow or halt the diffusion process if they reject or underuse the innovation." (p.1252)

Hage (1980) agrees, commenting that the "rank and file" (p.229) are typically the stakeholders who are most resistant to change. The findings of Beatty and Gordon (1988) correlate with the assertions of these researchers as they found that a "significant minority" of operating level personnel resisted CAD/CAM implementation.²

This research thus focuses on the input of CAD designers and CAM machine operators and attempts to predict the implementation success, as perceived by them, of CAD and CAM additions to CAD/CAM systems. Designers and machine operators are located at opposite ends of an ideal and fully integrated CAD/CAM system. The CAD designer spends approximately 80% of his/her time working at a CAD workstation. Such a workstation resembles a typical PC although it is imbued with significantly greater processing capabilities. The CAD designer specializes in detailed electrical or mechanical design work and is also involved in the generation of parts programs which guide manufacturing processes. Job titles for this type of operator include PCB CAD Designer and Design Engineer.

CAM machine operators, in contrast, spend almost all of their time at a machine on the shop floor. Such machines perform various tasks including the cutting of blocks and sheets of metal to create parts and assembly, such as the "stuffing" of integrated circuits and other

² It should be added, however, that resistance can also come from other sources. Leonard-Barton and Kraus (1985), for example, discuss "hedgers". These are "risk-averse managers" (p. 109) whose conspicuous apathy can frustrate the implementation of new technologies in the workplace.

components onto printed circuit boards.³ Responsibilities of machine operators include downloading parts programs, loading and unloading parts, organizing or adjusting machine tooling, monitoring machine activity, and inspecting output.

1.3 NEED FOR MANAGEMENT TO UNDERSTAND THE PERSPECTIVE OF OPERATING LEVEL PERSONNEL

Leonard-Barton and Kraus (1985) argue that a variety of different constituencies within the adopting organization must acquiesce with the implementation effort in order for it to be successful. Symon and Clegg (1991) add that each of these stakeholder groups has different "perceptions, objectives and expectations" (p.285) about the technology. It is crucial, thus, that the individual(s) guiding implementation "view the new technology from the perspective of each group" (Leonard-Barton, 1985, p.104). Referring particularly to operating level personnel, Lee (1989) states that "...management has to be aware that such innovations (CAD/CAM) require considerable adjustments on the part of end users..." (p. 233). Leonard-Barton and Kraus (1985) further develop this assertion stating "it is easy for managers to forget that benefits buried in the system, which they can see because of their position, may be totally invisible to the operators on whom the success of the innovation depends" (p.109). These sentiments are reiterated by Leonard-Barton and Deschamps (1988). Finally, Hage (1980) argues that the "rank and file do not share the same standards" (p.224) as more senior members of an organization, thus, they may not perceive the same performance gap as senior management and, accordingly, will not concur with the need for change.

³ Investments in computer numerically controlled (CNC), autoinsertion, and surface mount technology (SMT) equipment are all included in this research.

The findings of Beatty (1987) add strength to the above claims. In her study of factors affecting CAD operator productivity she found that managers and operating level personnel differed noticeably in their perceptions of the degree of operating level personnel participation and the extent of design productivity gains reaped as a result of switching to CAD from manual methods. Managers consistently cited greater productivity increases and greater participation of operating level personnel than the operators themselves perceived.

2.0 THE RESEARCH QUESTION

It has been discussed that the actions of end users can have a significant impact upon the implementation success of technological innovations. Furthermore, it has been argued that differences may exist between the perceptions of management and end users as to the necessity for, and repercussions of, new advanced manufacturing technologies in an organization. This leads to the goal of this research which is an examination of the influence of nine independent variables upon the implementation success, as perceived by operators, of CAD and CAM additions to CAD/CAM systems. This exercise should enlighten management as to the specific concerns of operators when an AMT is being implemented. This, in turn, should provide guidance as to how management practices during implementation could be refined to maximize the cooperation and enthusiasm of end users. Ideally, then, the implementation process will improve and companies will be able to reap much more significant benefits from their investments in CAD and CAM.

At the time of writing the proposal for this thesis an issue was raised regarding whether or not any first time users of CAD, CAM, or CAD/CAM still existed. This was a reasonable

question given that these technologies had been available for over a decade. As it turned out, no neophyte users were found and the study evolved slightly to focus upon significant additions of CAD and CAM to existing CAD/CAM systems. Despite the extensive experience which the participating companies already had with CAD/CAM, it was still felt that the nine independent variables were relevant given Adler's (1989) findings that even CAD/CAM "leaders" - in his case in the American electronics and aircraft manufacturing industries - were still grappling with implementation and integration issues. Anecdotal evidence provided by Ottawa-area operators further corroborated these assertions.

The variables to be examined are frequently cited in the AMT and IT implementation literature. They were drawn from this literature and from discussions with operating level personnel from Ottawa area high technology companies. These factors represent three of the four major categories of influences on technology adoption and implementation, Compeau (1992). These categories are: (1) characteristics of the organizational context; (2) characteristics of the system which was implemented, and (3) characteristics of the end user. The fourth category, job/task characteristics, is controlled for by analyzing CAD and CAM operator data separately.

Factors to be examined which are considered characteristics of the organizational context are: (i) the involvement of an effective technology champion; (ii) the extent of operating level personnel participation during the innovation process; (iii) the degree of top management support; (iv) the effectiveness of training provided to operating level personnel, and (v) the degree of "lateral" support received from other departments or divisions in the company which, although not recipients of the technology per se, were nonetheless affected by its

implementation. Characteristics of the CAD and CAM equipment include: (i) its usefulness, and (ii) the degree to which it was user friendly. Finally, characteristics of the individual operator include: (i) the age of the operator, and (ii) the extent of the operator's skills with similar technologies.

3.0 IMPLEMENTATION SUCCESS

The determination of the degree of implementation "success" can be achieved by examining various dimensions of the implementation process itself. In many ways it is a comparison of actual results to expected results. Gerwin and Kolodny (1992) suggested examining whether or not the system is solving the problems which propelled it into existence. Lee (1989) compared actual implementation time to planned implementation time. Beatty and Gordon (1991) compared the actual extent of component integration to what had been planned. They also suggested examining the extent of system utilization. The cost of the implementation effort and the incremental effect on productivity should also, logically, be included in any determination of success. A measure of implementation success, incorporating these dimensions, was created. It is described in Section 7.0 on page 26.

4.0 RESEARCH HYPOTHESES

4.1 CHARACTERISTICS OF THE ORGANIZATIONAL CONTEXT

4.1.1 HYPOTHESIS # 1: Impact of Technology Champion

Champions are unique and multi-skilled individuals whose rarity is to the detriment of many organizations. The champion is typically the driving force behind an innovation. The effective champion must be a visionary with considerable project management skills, must be politically astute, and be very determined.⁴ Although champions have been claimed to be crucial to the success of product innovations, only recently has their importance been studied during the implementation phase for a process technology.

Some researchers have stressed the need for a champion during the adoption and implementation phases of new technologies. Gerwin (1982) emphasises the need for a determined process champion to overcome resistance to making investments in CAM technologies. Leonard-Barton and Kraus (1985) advocate that "an innovation needs a champion to nurture it" (p. 108). Beatty (1992) is a very strong advocate of the need for an effective champion during AMT implementation. None of the ten companies which she studied achieved their goals without such an individual. She states:

"Companies without an effective technology champion found that implementation proceeded more slowly, remained restricted to a small corner of the organization, or, more important, did not achieve the objectives." (p. 52)

⁴ Beatty and Gordon (1991) cite champions' lobbying campaigns lasting as long as nine years.

She comments further about the positive influence of technology champions upon end users.

"The champion's vision, problem-solving, and implementation skills help build trust, acceptance, and commitment in those who are the essential operators of the new system." (p. 54)

The above discussion introduces the first hypothesis to be tested. This is:

H1: The more effective the technology champion, the more successful the implementation effort will be.

Despite their recognized importance, at least in the academic literature, companies implementing AMTs still give "little thought to the crucial role played by an enthusiastic mid-level champion" (Beatty and Gordon, 1991, p.73). It was intended that this research would help to identify the skills, attributes, and support which an effective champion must have. This information would be useful when selecting a champion and when determining appropriate training for this person.

4.1.2 HYPOTHESIS #2: Impact of Operating Level Personnel Participation

The literature presents an unclear picture regarding the need to involve end users throughout the entire process of technological innovation. Both blanket statements advocating user involvement in general and, on rare occasions, more focused recommendations advocating user involvement during specific activities have been made. Hage (1980) advises that change "requires the active participation and involvement of everyone" (p.223). Beatty and Gordon (1988) argue that involvement is a "powerful motivator" (p. 30) that can reduce the anxiety

caused by uncertainty when a new technology is being brought into an organization. And Lee (1989) contributes that the successful implementation of CAD/CAM "requires consultation and wide involvement" (p. 233). Furthermore, the consequences of not encouraging end user participation have been documented. Symon and Clegg (1991) describe pessimism, apprehension, and fear being rife amongst methods engineers who had not been involved in a CAD/CAM implementation effort. Similarly, Beatty and Gordon (1989) describe negative and inaccurate rumours being promulgated amongst designers who were not consulted during CAD implementation. In both cases anticipated productivity increases and payback were never achieved.

The literature also suggests, although less consistently, that pre-implementation involvement of users is important. Kimberly (1981) recommends that "participants" be involved in the creation of the implementation strategy for managerial innovations. Leonard-Barton and Kraus (1985) advocate that managers responsible for new technology implementation should learn about end user needs and idiosyncrasies. And Beatty (1986) recommended consulting designers during equipment selection.

Despite the exhortations described above, Beatty (1986) found that companies frequently did not solicit employee input especially during earlier activities of the innovation process. She was unable to determine whether or not CAD operator participation affected productivity with the new technology. Beatty and Gordon (1989) also found that only one of the ten companies in their study had conscientiously planned to improve communications with operating level personnel during CAD/CAM implementation.

The above discussion suggests that end user involvement throughout the innovation

process, not just during implementation, contributes to implementation success. Thus, the second hypothesis:

H2: The greater the participation of operating level personnel throughout the technological innovation process, the more successful the implementation effort will be.

The degree of participation was assessed by examining the extent to which operating level personnel perceived themselves to have had legitimate influence in a number of key decisions and activities which typically occur during the process of technological innovation. By measuring "influence" mere attendance at implementation meetings, for example, is distinguished from more substantial contributions where the input of end users was accorded due and sincere respect by management. Thus, the measures of operating level personnel participation attempted to capture both the breadth and depth of their involvement. While other researchers have argued that end user participation influences implementation success none have examined in detail during which activities, and to what degree for each of these activities, operators should be involved.

4.1.3 HYPOTHESIS #3: Impact of Top Management Support

Researchers advocate the need for top management support when a new technology is being brought into an organization. Gold (1982) asserts that "Support from the top is... essential" (p. 94) during the adoption of CAM technologies. Gerwin and Kolodny (1992) add that "strategic management's support for a new technology is generally believed to influence the rank and file not to resist" (p. 275).

Top management support is commonly manifested in one, senior level executive who may exist under various informal titles including the "sponsor" (Leonard-Barton, 1985), the "godfather" (Beatty and Gordon, 1989), and the "patriarch" (Beatty and Gordon, 1991). This individual is typically most active during new technology adoption although his/her involvement may extend throughout the innovation process. Leonard-Barton and Kraus (1985) add that the "sponsor" combines political astuteness with the power to ensure sufficient resources are dedicated to the project. Ideally, this individual also provides continuous support to the technology champion.

The ongoing research of Beatty and Beatty and Gordon has cast some doubt upon the precise impact of top management support during the implementation phase of new technologies. In her study Beatty (1987) found that top management support was inversely related to CAD operator productivity. This unexpected finding was explained by the potential misinterpretation of the questionnaire by respondents who may have understood "support" to mean "interference". At many of the companies she studied top management forced adoption upon the design staff and/or pushed hard for payback objectives to be met. The findings of her study may have been operator response to this undue influence of top management.

Although Beatty and Gordon (1992) concluded that the importance of top management support diminished during the implementation phase when "periodic expressions of interest and support plus protection from other executives" (p. 58) were all that was required, they had previously conceded that "Some further involvement (by top management) may well be necessary and desirable" (Beatty and Gordon, 1991, p. 91) during implementation. Despite this inconclusiveness it is still felt that top management support does contribute to CAD/CAM

implementation success. Thus, the third hypothesis of this study:

H3: The greater the support from top management during implementation, the more successful the implementation effort will be.

It is noted that in this research top management support is not presumed to be personified in any one specific individual, rather, respondents were encouraged to consider all individuals at the "Vice President's level and higher" as a single entity. Top management support is thus quite distinct from the technology champion variable.

4.1.4 HYPOTHESIS #4: Impact of Training

Many researchers recognize training as an influential variable during new technology implementation. Eason (1988) states that training is "the most obvious human requirement of implementation" (p.176). Lee (1989) agrees saying that "When an organization introduces CAD or CAM, a considerable investment in training is required..." (p. 229). Adler (1988) says that one of the "principal factors of (implementation) success..." (p. 44) is the training of operators. He urges "in-depth training of both a hands-on and a theoretical kind" (p. 45). Beatty and Gordon (1989) and Leonard-Barton and Kraus (1985) advocate training as a means to reduce resistance during implementation. Clegg et al. (1988) further elucidate the need for effective training stating that without it:

"...there may be substantial long-term costs in depending upon people who lack the necessary competence or motivation. Such personnel deficiencies are undoubtably expensive in the long run, through poor performance and/or through the need to replace or retrain unsatisfactory employees." (p. 99)

These arguments stem from the fact that the effective use of CAD/CAM "...requires the acquisition of certain new skills..." (Lee, 1989, p. 229). Similarly, Adler (1988) asserts that new technologies generally require an upgrading of skills before they can be used to their maximum potential. Lack of appropriate skills can also lead to demoralization on the part of employees which is eventually manifested in negative effects on productivity (Clegg et al., 1988).

Training remains a low priority of management despite the recognized need for it. Thompson (1990) states that management typically disregards training convinced that their staff are capable of learning new technologies on their own. Ghiara (1993) laments the typically reactive response of managers to training when new technology is brought into an organization. Foster (1991) goes further by criticizing Western-style managements' refusal to make training a priority when implementing CAD/CAM. This is explored further by Clegg et al. (1988) who cite a comparison between British and Japanese companies as proof. British firms dedicated only 0.01 per cent of revenues to training while their Asian counterparts invested 5 per cent.

Beatty (1987) examined the impact of training upon the skills and abilities of CAD operators. Although no correlation was found she concluded that this had more to do with the quantity, as opposed to the quality, of training provided. In most cases operators participated only once in a two to five day seminar conducted by the vendor. After this brief introduction they were left to their own devices to master the technology.

The above argument frames the fourth hypothesis of this thesis:

H4: The more effective the training of operating level personnel, the more successful the implementation effort will be.

4.1.5 HYPOTHESIS #5: Impact of Lateral Support

The construct of organizational support for an innovation is wide in scope. Its most common manifestations are in the form of top management support and, at least in the information technology literature, "encouragement of peers" and "technical support" (Compeau, 1992).

AMT implementation:

"depends on the cooperation of specialized departments and people who have not come into regular contact with each other in the past" (Beatty, 1992, p. 59).

The challenges which this presents are aggravated by the fact that:

"the orientations, tasks, environments, goals, and reward systems (of such departments) are radically different in most companies" (Beatty and Gordon, 1988, p. 28).

AMT implementation efforts frequently engender feelings of jealousy and/or insecurity amongst those not receiving the technology. Physical distance, the explicit isolation of the receiving group, and resulting incompatibilities between technologies of the receiving and non-receiving constituencies can heighten these potentially destructive feelings.

Discussions with operating level personnel have added another type of "support". This, for the purpose of this thesis, has been defined as "lateral" support. This term describes cooperation and assistance from those groups, divisions, or departments located at a similar level in the organizational hierarchy, who, although not recipients of the technology itself, are still affected by its implementation. These groups, divisions, or departments are affected because

their activities are intertwined with the activities of the department receiving the technology or because the new technology raises issues which concern their traditional responsibilities, for example, for technology maintenance in the organization.

Although no rigorous study of the impact of lateral support upon implementation success was found in the literature, references to similar notions do exist. Dean (1987) discusses the concept of "solidarity" which he defines as "a combination of consensus and commitment" (p.136) amongst organizational subunits as to the need for investment in new AMTs. The breadth and depth of this solidarity, he argues, can significantly influence top management decision making. Beatty (1992) describes a dispute at one organization between the MIS and engineering departments over "ownership" of the CAD/CAM hardware. A lack of cooperation persisted between the two departments resulting in "few improvements" being made to the system. Finally, Beatty and Gordon (1988) describe friction existing between the design/engineering and manufacturing divisions at another of their test sites.

In conclusion, feelings of jealousy and insecurity amongst constituencies not receiving the technology, exasperated by differences in the cultures of organizational sub-units, can contribute to a lack of support for that unit of the company which is receiving the technology. This leads to the fifth hypothesis of this study:

H5: The greater the lateral support received during implementation, the more successful the implementation effort will be.

Operating level personnel from organizational departments where CAD or CAM had been implemented were queried as to the extent of lateral support which they received.

4.2 CHARACTERISTICS OF THE SYSTEM

4.2.1 HYPOTHESES #6 AND #7: Impact of Usefulness and Ease of Use

Discussions with operating level personnel from Ottawa area high technology companies suggested that characteristics of the CAD/CAM system itself could effect implementation success. "Usefulness" and "user-friendliness", as perceived by operators, were the two system characteristics mentioned. The literature corroborates the legitimacy of this phenomenon. Davis (1989) did a comprehensive study of the topic. He concluded that:

"from multiple disciplinary vantage points, perceived usefulness and perceived ease of use are indicated as fundamental and distinct constructs that are influential in decisions to use information technology." (p. 323)

Following an extensive literature review and several iterations of rigorous testing he produced measures of "usefulness" and "ease of use". These theoretical constructs he defined, respectively, as "the degree to which a person believes that using a particular system would enhance his or her job performance" (p.320) and "the degree to which a person believes that using a particular system would be free of effort" (p. 320). Davis found that both of these factors "were significantly correlated with self-reported indicants of system use" (p.333).

The application of Davis' findings to CAD/CAM implementation success, however, must be pursued cautiously. Davis examined the effect usefulness and ease of use had on self-reported measures of current and predicted future usage, only. Utilization is but one of several dimensions which constitute the measurement of implementation success as defined in this research. Furthermore, Davis examined the implementation of fairly standard office technologies including E-Mail and text editor and graphics packages. These differ significantly

from a CAD/CAM system in terms of complexity and function.

In contrast to the findings of Davis (1989), Beatty (1987) found that "system quality" did not correlate with CAD operator productivity. This conclusion is surprising given that "system quality" did include measures of usefulness and user-friendliness.

The uncertainty surrounding the exact impact of system characteristics upon CAD/CAM implementation success warrants further study. Thus, the following two hypotheses were tested:

H6: The greater the perceived usefulness of the system, the more successful the implementation effort will be.

H7: The greater the perceived ease of use of the system, the more successful the implementation effort will be.

4.3 CHARACTERISTICS OF THE END USER

4.3.1 HYPOTHESES #8 AND #9: Impact of User Age and Breadth of Skill with Similar Technologies

Discussions with operating level personnel at Ottawa area companies revealed that characteristics of individual operators might impact CAD/CAM implementation success. The operator's age and breadth of knowledge with the technology, in particular the former, were frequently mentioned. Much has been written about these two variables. Compeau's (1992) review of the information technology literature concluded that correlations between user age and system use were "weak and inconsistent" (p. 20). Levi et al (1992) concluded that the "research evidence is mixed" (p. 134) concerning the relationship between demographic characteristics of users and their acceptance of new technology. They concluded in their own study, however, that age did not correlate significantly with employees' beliefs about technological change.

Webster (1992) examined age as a factor affecting individuals' abilities to learn new technologies. She cites research which concluded that older workers "took significantly longer to complete microcomputer software training" (p. 7) and "exhibited significantly lower performance than did younger trainees on an objective test of software knowledge" (p. 7). Her own research, however, did not reach this same conclusion although the scope of her study was limited to employees at one university who were learning selected functions of the Wordperfect word processing package. Given the discrepancy between the findings of recent research and the claims of operating level personnel it was felt that the impact of end user age should be examined. Thus, the eighth hypothesis:

H8: The older the operating level personnel who are to use the new technology, the less successful the implementation effort will be.

The second characteristic of end users which may affect implementation success is their breadth of knowledge with similar types of technology. Like age, this variable has also been examined in the literature. Leonard-Barton and Deschamps (1988) state that "end-user evaluations of the innovation...depend heavily upon each individual's personal interests, needs, and skill" (p. 1253). Levi et al (1992) note that "research has found a mixed relationship between technical skills and attitudes toward technology" (p. 135) although they concede that this finding was drawn from studies of fairly unsophisticated computing technologies. They hypothesized, in their own research conducted at five "technologically innovative" (p. 140) electronics companies, that technical skills would relate to end user attitudes towards technological change. In fact, no significant relationship was found. In her study of factors affecting CAD operator productivity, Beatty (1987) concluded that "facility with using

computers" was significantly correlated to user productivity with CAD. Leonard-Barton and Deschamps (1988) studied the mediating role of end user characteristics upon managerial influence to adopt new technologies. In their examination of the adoption of expert systems by salespeople at a computing technology company they hypothesized that the less technically skilled the user, the more he/she would attribute new technology adoption to encouragement from management. The logic of the researchers was that technology-related skills provide users with greater "access" to a given technology, thus enabling adoption to occur with a minimum amount of urging from management. For their study, Leonard-Barton and Deschamps defined "technical skill" as skill in software use. This hypothesis was not supported.

The inconclusive findings of the research discussed above call for further examination of the effect of end users' technological skills upon CAD/CAM implementation success. Thus, the ninth and final hypothesis:

H9: The more operating level personnel are skilled in similar types of technology, the more successful the implementation effort will be.

Operating level personnel were asked to comment upon the extent of their skills with technologies similar to those which were implemented. The work of Beatty (1987) and Leonard-Barton and Deschamps (1988) was used to guide the creation of the measurement devices which were employed.

5.0 SUMMARY OF RESEARCH HYPOTHESES

This research planned to test the influence of nine independent variables upon the implementation success, as perceived by operators, of CAD and CAM additions to CAD/CAM systems. These nine variables were delineated by whether they were characteristics of the organizational context, of the system which was implemented or of the individual end user. Figure 1 summarizes these variables and their hypothesized impact upon implementation success.

Figure 1: Independent and Dependent Variables

6.0 DATA COLLECTION

CAD and CAM operators and managers from Canadian manufacturing companies which had made a significant investment in these technologies between one and four years ago were queried. Originally, it had been planned that only investments which had occurred at least eighteen months before data collection would be included. This threshold was drawn from the work of Symon and Clegg (1991) and Beatty (1992) who concluded that routinization of new CAD/CAM systems began after a period of approximately this duration had past. This parameter was adhered to in most cases. The convenient availability of local companies willing to participate, however, warranted the violation of this restriction on three occasions. In these three cases implementation had occurred one year before data collection.

The inclusion of implementation efforts which occurred up to four years in the past was deemed acceptable as this parameter had been used in previous AMT research done by Tyre and Hauptman (1992). Based on this precedent it was concluded that the recollection of events that far in the past was within the bounds of human recall.

The identification of potential companies was carried out through various means. Vendors of CAD and CAM equipment and nonprofit AMT research consortiums were approached. On the manufacturing side, in particular, the 1993 Census of NC/CNC Installations conducted by the Canadian Machinery & Metalworking Magazine proved useful. Finally, contacts in the Ottawa area, including members of the Manufacturing Managers' Network, also were very helpful.

Data were collected between March and October of 1993. Altogether, nineteen organizations submitted usable questionnaires. These companies varied by size, industry, and

geographic location. Table 1 on the next page provides summary information about them. It is stressed that separate investments in design and manufacturing equipment were investigated. Typically these investments constituted significant contributions in functionality to the organizations' existing CAD/CAM capabilities. Although this study originated as an examination of CAD/CAM implementation success, no incidents were ever encountered where a simultaneous investment in design and manufacturing equipment had been made. With this in mind, it was felt more appropriate to consider this study an investigation of the implementation of CAD and CAM additions to CAD/CAM systems. References to "CAD/CAM" in the questionnaires should be considered as "CAD" or "CAM", the difference having been explained to respondents.

It is interesting to note that almost all of the managers rated their companies highly in terms of their degree of experience with CAD/CAM technologies. This is not too surprising when one considers that none of the companies were first time users of CAD or CAM, as mentioned above. The amount of money invested in the respective piece(s) of equipment, as a proportion of annual sales, ranged from 0.39% to 18.7% for the seventeen organizations which agreed to provide this information. At the remaining two organizations the researcher was assured that the investment was "significant".

Operators and managers were unanimous in their response to the question: "From where within the organization did the recommendation to make the specific investment in CAD/CAM come?"⁵ For all of the thirteen companies which made investments in CAM equipment, both operators and managers responded that the recommendation came from middle and senior

⁵ Q-79 on the operator questionnaire and Q-3 on the manager questionnaire.

TABLE 1: SUMMARY INFORMATION ON PARTICIPATING COMPANIES

SITE	# OF EMPLOYEES	COMPANY INDUSTRY	TYPE OF INVESTMENT	OPERATORS SURVEYED	MANAGERS SURVEYED	DEGREE OF EXPERIENCE*
1	175	military	CAD	8	4	4
2	340	aerospace	CAD	7	1	4
3	1,400	telecommunications	CAD	4	2	3.5
4	35	mould making	CAD	2	1	4
5	250	electronics	CAD	1	1	5
6	60	electronics	CAD	6	2	4.5
7	14	aerospace	CAM	2	1	4
8	15	aerospace	CAM	1	1	5
9	325	railroad equipment	CAM	1	1	4
10	20	sheet metal fabrication	CAM	1	1	3
11	27	aerospace	CAM	1	2	4
12	18	aerospace	CAM	2	1	4
13	40	sheet metal fabrication	CAM	1	1	2
14	500	auto parts	CAM	1	1	4
15	900	military	CAM	1	1	4
16	600	aerospace	CAM	2	1	3
17	1,300	telecommunications	CAM	4	2	4
18	3,000	computing equipment	CAM	3	1	5
19	1,350	data communication products	CAM	6	3	3
TOTALS				54	28	

* Response of managers to the statement: "Personally, I feel my company is very experienced with CAD/CAM technologies."; 1 = Strongly Disagree, 5 = Strongly Agree. Median response is provided where more than one manager. Median for all 28 managers = 4.0.

management. Results were the same for five of the six organizations which implemented CAD. At the sixth company, Site 6 in Table 1, operators and managers agreed that the recommendation came from CAD designers.

Job titles for CAD operators usually incorporated the word "design". Examples included "senior hardware designer" and "design engineer". Only four of the twenty-eight CAD operator respondents identified themselves either as drafters or draftsmen. All of these individuals came from the same organization. The twenty-six CAM operator respondents typically identified themselves as either CNC or SMT machine operators.

Preliminary contact with senior CAD and CAM managers was done by telephone. The nature of the study was explained and their participation was solicited. An introductory kit, consisting of an information sheet (Appendix C) and copies of the questionnaires, was faxed to the manager and served as a useful means by which to legitimize the study.

With the assistance of the company contact person a specific and significant investment in CAD or CAM equipment was identified.⁶ The managers who were responsible for bringing this equipment into the organization and the original operators were identified. Usually, copies of the questionnaires, explicit instructions to the respondents regarding their completion⁷, and large manila envelopes were left with the contact person. Upon completion, which was usually encouraged by several friendly phone calls, the researcher was summoned to retrieve them.

In four instances data were collected via mail survey using the advice of Dillman (1978).

⁶ This process was normally quite easy as both the Canadian Machinery & Metalworking 1993 Census and equipment vendors provided specific information about the investments made.

⁷ For examples of instructions to operator and manager respondents refer to Appendices D and E respectively.

In these cases copies of the questionnaires, relevant instructions, and self-addressed return envelopes were couriered to the company and returned via post.

6.1 DATA COLLECTION INSTRUMENTS

Data were collected using two structured questionnaires. The first, and larger questionnaire, Appendix A, asked operating level personnel who were present during the implementation effort to rate various dimensions of the dependent and independent variables. In the second questionnaire, Appendix B, managers responsible for the implementation effort were asked to assess implementation success only.

The questionnaires for managers and operators were pretested by four and eight individuals respectively. The insignificance of the modifications which resulted from these sessions warranted the inclusion of these specific questionnaires in the final sample.

7.0 MEASURES FOR THE DEPENDENT AND INDEPENDENT VARIABLES

Time and cost factors prohibited the use of objective measures of implementation success. To address this weakness, both operating level personnel and managers were asked to rate success using multi-item scales created for this study. It was hoped that a "true" indicator of success would emerge upon consideration of input from both of these constituencies. Success was measured using seven 5-point Likert-type scales, examples of which can be found in Section G of Appendix A. Questions Q-70 to Q-72 prompt respondents to comment upon the degree to which the system was successfully incorporated into work activities, the extent of system utilization, and the degree to which implementation was a success. Responses to these three

scales vary between 1 = Strongly Disagree and 5 = Strongly Agree. The remaining four questions, Q-73 to Q-76, prompt respondents to compare actual outcomes of the implementation effort to what had been originally planned. These scales vary between 1 = Much Less and 5 = Much Greater. All of the seven items were verified as appropriate by both operators and managers during structured interviews which occurred during the finalization of the thesis proposal and the questionnaires.

All of the independent variables, except user age, were measured using 5-point multi-item scales. Almost exclusively, a score of five indicated that a greater amount of the dimension being measured had been present. This implied that a more positive outcome had occurred, for example, that training was "more" appropriate or that lateral groups collaborated "more" regularly during implementation.

The effectiveness of the technology champion was assessed using twelve 5-point Likert-type scales. The scales encompassed champion skills, attributes, and manifestations of organizational support which the literature claims constitute "effectiveness". Section D of Appendix A details this measure.

Operator participation was measured using nine, 5-point Likert-type scales. These are Q-51 through Q-59 in Section E of Appendix A. As well, questions Q-60 through Q-64, in the same section, attempted to gauge types of influence used by operators and the prevalence and effectiveness of implementation teams.

Top management support was measured using eight, 5-point Likert-type scales. These are in Section C of Appendix A. These scales encompassed manifestations of support including the extent to which top management provided resources and encouraged cooperation between

groups affected by the implementation effort.

The "effectiveness" of training was measured using eight, 5-point Likert-type scales as detailed in Section B of Appendix A. These scales captured the amount, timing, and appropriateness of the training received. These dimensions of training effectiveness were drawn from the literature and were approved by Ottawa area CAD and CAM operators as relevant. Some less structured questions were included to flesh out the examination of this independent variable.

Lateral support was measured using five, 5-point Likert-type scales. These are presented in Section F of Appendix A. The scales captured dimensions of support including the extent to which lateral groups cooperated with, and provided information to, the technology receiving department.

Davis' (1989) proven six-item measures were employed to gauge system usefulness and ease of use. Refer to questions Q-1 to Q-6 and Q-7 to Q-12, respectively, for a break down of these variables.

Respondents were asked to provide their exact age in Q-80, in Section H of Appendix A. By leaving the answer open-ended, options for data analysis could remain diverse.

Operator skill with similar types of technology was measured using a three-item scale. Questions Q-13 to Q-15 prompted respondents to comment upon the extent to which they were skilled with the same type of equipment which was implemented, with similar types of equipment, and with "computerized equipment of any kind".

8.0 DATA ANALYSIS

Data were analyzed using the SPSS for Windows, Version 6, statistical software package. Data analysis proceeded after the recoding of Q-30, Q-75, and Q-76 on the operator questionnaire, the latter two items being the same as Q-9 and Q-10 on the manager questionnaire. For these items, a higher score, ie. near five, indicated a more negative outcome. For example, in Q-30, a score of five indicated strong agreement to the statement "Top management pressured us for immediate productivity gains using the new equipment". Scores for this item, and Q-75 and Q-76 as well, were thus recoded to conform with the majority of the items in the questionnaire for which a high score indicated a positive outcome.

CAD and CAM operator data were analyzed separately. Differences in the tasks which these people perform and the types of equipment which they use support this procedure. As mentioned earlier, this also controls for job/task characteristics which are a category of influences on technology adoption and implementation.

8.1 PRELIMINARY TESTS OF NORMALITY

Given the predominance of ordinal data, nonparametric statistical tests were mainly used, in order to play it safe. However, the dearth of appropriate nonparametric tests for analyzing the impact of multiple variables simultaneously necessitated the use of parametric methods also. To support the use of such tests, namely hierarchical regression in Section 8.5, it was considered prudent to attempt to prove the normality of the distribution of responses for each of the items. Thus preliminary tests of skewness and kurtosis were done using Z tests, as demonstrated by Tabachnick and Fidell (1989).

Data for most of the sixty-four Likert-type scales in the operator questionnaire, for both the CAD and CAM sides, proved to be normally distributed at $\alpha=0.001$. Of interest are the striking similarities between the design and manufacturing environments in regards to those few items for which the data were skewed. On the CAD side, seven items proved to be skewed at $\alpha=0.01$. Of these, five were from the end user participation variable. On the CAM side, ten items proved to be skewed at $\alpha=0.01$. Of these, six were from the participation variable. Both CAD and CAM operators perceived themselves as having had very little personal influence in the nine activities and decisions which made up the measurement of this variable, with median scores for all nine items, for both types of operators, fluctuating between only 1 and 2.5 on a 5-point scale. The implications of this upon implementation success will be analyzed in Section 8.3.1.2.

Also of note, for both CAD and CAM operators, responses to Q-72, "Overall, I think the CAD/CAM implementation was a success", were skewed, at $\alpha=0.01$, towards the high end of the 5-point Likert-type scale indicating overwhelming agreement to the statement.

8.2 PRELIMINARY TESTS OF RELIABILITY

Tests of reliability of the multi-item measures were done using Cronbach's α and the Spearman Rank Correlation Coefficient, the latter having been recommended for use with ordinal data by both Davis and Cosenza (1988) and Norusis and SPSS Inc. (1993a).

Alpha scores are displayed in Table 2 on page 33. Except for "CAD/CAM Implementation Success", alpha scores were quite acceptable for all of the variables from both the design and manufacturing environments. Given the importance of the dependent variable it

was felt that this measure should have an alpha closer to 0.7. The first test of reliability, however, produced alphas approximating only 0.50 for both designers and machine operators. A decision was made to eliminate the minimum number of items in order to achieve a higher alpha. Based upon the largest negative Spearman rank coefficients, the impact of individual items was assessed. After several iterations, each involving examination of the Spearman rank coefficients and numerous scatterplots, it was felt that two items should be eliminated.⁸ The resulting new measure of implementation success, for the CAD side only, has $\alpha=0.66$.

The initial, seven item measure of implementation success for the CAM side was also inconsistent, having an alpha of only 0.54. The same process as discussed above was repeated. This resulted in the elimination of the same two items. The resulting five item measure has $\alpha=0.75$. This strategy of emphasizing a reliable, albeit reduced, multi-item scale was felt appropriate given the importance of the dependent variable.

On a site-by-site basis, for CAD and CAM data separately, the mean of the managers' scores on "total implementation success" was correlated with the mean of the operators' scores on "total implementation success", "total implementation success" being the mean of the scores on the five items which constitute the "implementation success" variable. For CAD, an insignificant Spearman Rank Order Correlation Coefficient (r) of only 0.09 was produced. Accordingly, insignificant coefficients were also produced when each of the five items were examined individually. These findings are very questionable given the small sample size, $N = 6$, and the lack of variation in all of the scores.

⁸ The two items were Q-75 and Q-76 from Appendix A. These statements prompted the respondent to comment upon the actual amount of time and the actual cost to implement the system.

The CAM data, $N = 13$, produced $r = 0.79$, significant at $\alpha=0.01$. In addition, positive correlation coefficients were produced for all five of the items which constitute implementation success. Coefficients for three of these items, Q-70, Q-71, and Q-73, were significant at $\alpha=0.05$.

TABLE 2: CRONBACH'S α INDICATOR OF RELIABILITY OF MULTI-ITEM SCALES

VARIABLE	CRONBACH'S α CAD OPERATORS ^a	CRONBACH'S α CAM OPERATORS ^b
Effectiveness of Technology Champion	0.92	0.86
End User Participation	0.92	0.78
Top Management Support	0.73	0.92
Effectiveness of Training	0.75	0.86
Extent of "Lateral" Support	0.86	0.89
Usefulness	0.91 ^c	0.83 ^c
Ease of Use	0.82 ^d	0.93 ^d
Skill With Similar Technologies	0.86	0.63
CAD/CAM Implementation Success	0.66	0.75

^a $N = 28$ except for the "Effectiveness of Technology Champion Variable" where $N=13$ and the "Effectiveness of Training" variable where $N = 9$.

^b $N = 26$ except for the "Effectiveness of Technology Champion" variable where $N = 13$ and the "Effectiveness of Training" variable where $N = 19$.

^c Davis (1989) achieved $\alpha = 0.98$

^d Davis (1989) achieved $\alpha = 0.94$

In addition to these findings total manager and operator mean scores on each of the five items in implementation success were very similar for both CAD and CAM data. It appears, despite the results of the test of correlation for CAD data, that the use of subjective measures of implementation success is acceptable.

The measures of the dependent and independent variables, by and large, were consistent. Their use in future research is plausible.

8.3 TESTS OF HYPOTHESES

Given the high reliability of each of the multi-item scales, tests of hypotheses were carried out on new, "total", variables. For example, a new variable called "total top management support" was used, this being the mean of the eight items which constituted the construct "top management support". In most cases the degree of association between the "total" version of an independent variable and "total implementation success" was assessed using Spearman's Rank Order Correlation Coefficient (r). Also, where warranted, a more detailed examination of correlation coefficients between individual items which constituted an independent variable of interest and the five items which constituted "implementation success" are presented.

Numerous scatterplots, boxplots, and individual questionnaires were scrutinized for outliers. This investigation concluded that there were no grounds for excluding any of the data points.

Given that this study is an examination of factors affecting operators' perceptions of implementation success, only their responses were used for the dependent variable, unless it is explicitly stated otherwise.

8.3.1 CHARACTERISTICS OF THE ORGANIZATIONAL CONTEXT

8.3.1.1 HYPOTHESIS #1: Impact of Technology Champion

Regrettably, data collection for the "Effectiveness of Technology Champion" variable did not proceed as had been intended. The researcher had assumed that in each organization one, distinct individual had existed who "actively promoted and directed the incorporation of the new CAD/CAM technology".⁹ This thinking was naive.

In five of the six organizations which implemented^d CAD, and nine of the thirteen which implemented CAM, at least one champion was identified. All champion(s) were rated quite highly as evidenced by the responses to questions Q-39 through Q-50. Mean scores from designers ranged from 3.31 to 4.46, on a 5-point scale, and between 3.77 and 4.54 for machine operators. Quite conceivably, these universally high responses may have been a result of the wording of Q-37 which may have encouraged respondents to identify a champion only if an exceptionally dynamic and highly regarded individual had been involved. This did not fully satisfy the aims of the researcher who, during the construction of the questionnaire, heard anecdotes from operators detailing bad experiences with ineffective champions. The objective of this research was to capture data concerning both effective and ineffective champions. Unfortunately, this was not achieved.

Table 3 provides detailed information about the companies where champion(s) were identified and about the champion(s) themselves. Results are inconsistent. In Site 1, for example, respondents either: (1) indicated that no champion existed; (2) identified one specific

⁹ This phrase is taken from Q-37 which was used to ask respondents whether or not a champion had existed.

TABLE 3: SUMMARY INFORMATION ON ORGANIZATIONS WHERE AT LEAST ONE TECHNOLOGY CHAMPION WAS IDENTIFIED

Type of Equip.	Site	Total # of Employees	Median Degree of Experience With CAD or CAM	# of Respondents Who Indicated no Champion	# of Respondents Who Indicated 1 Champion	# of Respondents Who Indicated 2 Champions	# of Different Individual Champions Identified	Median Score on Champion(s) "Total Effectiveness"	Median Score on "Total Implementation Success"
CAD	1	175	4	2	5	1	3	4.0	3.3
	2	340	4	5	2	0	1	4.2	4.0
	4	35	4	0	2	0	1	3.8	3.8
	5	250	5	0	1	0	1	3.9	3.8
	6	60	4.5	4	1	1	2	3.0	3.9
	7	14	4	0	2	0	1	3.5	4.6
	8	15	5	0	1	0	1	4.4	4.8
CAM	9	325	4	0	1	0	1	3.9	2.2
	11	27	4	0	1	0	1	4.2	4.2
	14	500	4	0	0	1	2	3.3	3.6
	15	900	4	0	0	1	2	4.8	4.2
	16	600	3	0	2	0	1	4.4	4.3
	17	1,300	4	3	1	0	1	4.7	4.1
	19	1,350	3	3	3	0	3	4.0	3.8

^a The variable "Total Effectiveness" is the mean of the twelve dimensions of champion effectiveness, Q-39 through Q-50. This score is based on a scale running from one to five with five indicating greater "effectiveness". Calculation of the "Median Score on Champion's 'Total Effectiveness'" only includes those operator respondents from the given site who identified at least one champion.

^b The variable "Total Implementation Success" is the mean of the five items which constituted the measure of implementation success, Q-70 through Q-74. This score is based on a scale running from one to five with five indicating greater "success". Calculation of the "Median Score on 'Total Implementation Success'" includes all operator respondents from the given site.

champion per questionnaire or; (3) indicated two individuals on the same questionnaire. At this site, consequently, three different champions were identified. As well, a few designers, all of whom identified themselves with the exact same job title, formed two distinct groups, each identifying a different individual.

The results from Table 3 suggest two inseparable issues. These are that at some of the companies there were multiple champions and/or there were conflicting responses as to the number of champions. The latter issue, most prevalent at Sites 1, 2, 6, 17, and 19, indicates low inter-rater reliability. It was felt that by examining the technology champion variable using both the organization and the individual as the unit of analysis, that the vagaries in the data would be compensated for somewhat. Thus, firstly, total implementation success was compared between those organizations where operators unanimously indicated that no champion had existed and those organizations where at least one of the operators indicated that at least one champion had existed. For the latter type of organization, an assumption was made that at least one champion had existed even though some of the operators may have indicated that no champion had been involved. The uneven distribution of respondents and companies which did and did not identify at least one champion prohibits the use of statistical analysis. A cursory examination of the comparison was still felt to be useful. Results are presented in Table 4.

**TABLE 4: COMPARISON OF ORGANIZATIONS
WHICH DID AND DID NOT HAVE A TECHNOLOGY CHAMPION**

Type of Respondent	Presence/Absence of a Champion	N	Median Score on Total Implementation Success
CAD	At Least 1 Champion Identified (Sites 1,2,4,5,6)	5	3.6
	No Champion Identified (Site 3)	1	3.9
CAM	At Least 1 Champion Identified (Sites 7,8,9,11,14,15,16,17,19)	9	4.2
	No Champion Identified (Sites 10,12,13,18)	4	4.0

Findings on the CAD side are surprising. Here implementation success was rated higher in the one organization where operators unanimously did not identify a champion. Findings from the manufacturing side are more in line with expectations as implementation success was rated slightly higher in organizations where at least one champion was identified.

In addition, data were further examined using the individual as the unit of analysis. The breakdown of respondents, by number of champions identified, is presented in Table 5.

TABLE 5: TECHNOLOGY CHAMPION(S) IDENTIFIED

Type of Respondent	No Champion Identified		1 Champion Identified		2 Champions Identified	
	N	Median Score on "Total Success"	N	Median Score on "Total Success"	N	Median Score on "Total Success"
CAD Operators	N = 15	4.0	N = 11	3.6	N = 2	3.8
CAM Operators	N = 13	4.0	N = 11	4.4	N = 2	3.9

Given the extremely low number of people who identified two champions, it was decided to combine the middle and right groups in Table 5. The analysis which follows thus considers only those respondents who identified at least one champion.

In both the design and manufacturing environments thirteen respondents indicated that at least one champion had existed. Two-tailed tests of the correlation between "total effectiveness" and "total implementation success" were done using Spearman's rank correlation coefficient (r). The test statistic is:

$$t = r \sqrt{\frac{N-2}{1-r^2}}$$

where t critical is from the Student's t distribution with $N-2$ degrees of freedom. For both CAD and CAM operators, t critical is 1.796 at $\alpha=0.10$. The null hypothesis tested was:

HO-1a: There is no correlation between total champion effectiveness and total implementation success.

Results of the test and other relevant data are presented in Table 6. For both CAD and CAM operators, t calculated is less than t critical at $\alpha=0.10$; thus the null hypothesis cannot be rejected. This analysis suggests that the involvement of an effective technology champion does not influence implementation success, as perceived by operators.

**TABLE 6: RESULTS OF THE HYPOTHESIS
TEST FOR THE TOTAL EFFECTIVENESS VARIABLE**

Type of Respondent	Median Score on "Total Effectiveness"	Spearman Correlation Coefficient (<i>r</i>)	<i>t</i> calculated
CAD (N = 13)	3.83	0.10	0.32
CAM (N = 13)	4.00	0.19	0.65

In addition to the above analysis, the degree of association between each of the twelve items in total effectiveness and the five items which constitute implementation success was analyzed using the Spearman rank test. Similar to what was previously found, results suggested that, by and large, no association exists between the individual items of the independent and dependent variables. Of the sixty coefficients which were produced for both the design and manufacturing environments¹⁰, only five were significant and positive for the CAD side and only two for the CAM side. These seven coefficients had no apparent order or pattern. It had been hoped that this analysis would provide information regarding what skills and organizational support a good champion must have. Unfortunately this was not possible.

Further data analysis was done after the "Effectiveness of Technology Champion" variable had been reduced to a dichotomous, Yes/No, format. Here the complete absence of a champion was compared to instances where there was at least one champion. The Mann-Whitney test for two independent samples was used to compare the scores on total implementation success between the two groups. This test is recommended by both Norusis and SPSS Inc. (1993a) and Siegel and Castellan, Jr. (1988) for use with ordinal data. Scores on total implementation

¹⁰ 12 items which constituted the "effectiveness of technology champion" variable X 5 items which made up "implementation success"

success for those who did and did not identify a champion(s) are ranked and the sample distributions of these ranks are compared. This procedure was done separately for designers and machine operators. The hypothesis tested was:

H0-1b: There is no difference in total implementation success when no champion or at least one champion was identified.

Probability levels associated with the Z scores produced by this 2-tailed test and other relevant data are presented in Table 7. For both types of operators these levels are greater than the preset α of 0.10. Thus, the null hypothesis cannot be rejected. The results imply that the presence or absence of an effective champion(s) has no influence upon operators' perceptions of total CAD or CAM implementation success.

TABLE 7: RESULTS OF THE MANN-WHITNEY TEST FOR THE TECHNOLOGY CHAMPION VARIABLE

Type of Respondent	Champion(s) Identified		No Champion Identified		Probability level from Z score
	N	Median Score on "Total Success"	N	Median Score on "Total Success"	
CAD Operators	N = 13	3.6	N = 15	4.0	0.43
CAM Operators	N = 13	4.2	N = 13	4.0	0.19

For designers, the findings are congruent with those displayed in Table 4 where the organization was the unit of analysis. In both of these tables total CAD implementation success was higher when no champion(s) was identified.

Overall, the findings are interesting when compared to those of Beatty (1992). She claimed an effective champion was "absolutely necessary to project success" (p. 52) and none

of the ten companies which she studied achieved their goals without such an individual. In this study many of the companies successfully implemented new technologies without a champion, this finding being stronger for companies which implemented CAD.

The results produced are extremely suspect. The notion that the involvement of an effective technology champion has no influence upon implementation success contradicts the findings of a large body of research. Perhaps the twelve dimensions of "effectiveness" used here do not capture the essence of a good champion although this is unlikely given the thoroughness of the literature review from which they were drawn. However, the dubious efficacy of the data collection devices and the lack of variation in responses to both the "total champion effectiveness" and "total implementation success" variables are noted as limitations. The researcher does not advocate that organizations disregard the importance of a champion during CAD or CAM implementation.

8.3.1.2 HYPOTHESIS #2: Impact of Operating Level Personnel Participation

As mentioned earlier, both CAD and CAM operators perceived themselves as having had very little personal influence in the nine decisions and activities which constituted the "end user participation" variable. Tests of correlation between "total end user participation" and "total implementation success" using Spearman's rank correlation coefficient (r) were done. For CAD operators ($N = 28$), t critical is 1.706 at $\alpha=0.10$. For CAM operators ($N = 26$), t critical is 1.711 at $\alpha=0.10$.

The hypothesis tested was:

HO-2: There is no correlation between total end user participation and total implementation success.

Results of this 2-tailed test and other relevant data are presented in Table 8. Median scores on "Total End User Participation" are based on scale values running from one to five. For both CAD and CAM operators, t calculated is less than t critical at $\alpha=0.10$ thus the null hypothesis cannot be rejected. The analysis implies that end user participation does not influence operators' perceptions of implementation success.

**TABLE 8: RESULTS OF THE HYPOTHESIS TEST
FOR THE TOTAL END USER PARTICIPATION VARIABLE**

Type of Respondent	Median Score on "Total End User Participation"	Spearman Correlation Coefficient (r)	t calculated
CAD Operators	1.50	0.05	0.24
CAM Operators	1.67	0.01	0.04

Given the analysis above, it follows that there would be no positive association between individual items of the independent and dependent variables, as well. A Spearman rank test produced no significant and positive correlation coefficients between any of the nine items in end user participation and the five items in implementation success for the manufacturing environment. Results for the design side were almost identical with only two significant and positive correlation coefficients being produced.¹¹

It would appear, however surprisingly, that operator "personal influence" has no impact upon their perceptions of CAD or CAM implementation success. Intuitively these results are difficult to accept. Similar to the results of the technology champion variable, they contradict the assertions of numerous researchers. It is conceivable that respondent bias may have

¹¹ These are: (1) $r = 0.46$, between Q-58 and Q-73 and (2) $r = 0.37$, between Q-58 and Q-71. Q-58 concerns "setting productivity standards for the equipment".

contributed to the low participation scores. That is, a grudge against a manager or the organization as a whole may have prompted an operator to exaggerate his/her lack of influence. This is noted as a limitation of this analysis.

Questions Q-60 through Q-64 contributed more information to the analysis of the participation variable. It should be reiterated that the purpose of these five questions was not to measure participation, per se, but rather, to enrich the findings for this independent variable.

Results for questions Q-60 and Q-61 were very similar for both types of operators. Q-60 asked respondents to indicate what types of influence they used in regards to the nine decisions and activities which made up the end user participation variable. Both CAD designers and CAM machine operators heavily favored responses (a), they received information; (b), they provided information; and (c), they participated in decision making. Only three CAD operators indicated option (d), that they exercised a veto. None of the CAM operators did so.

Q-61 asked respondents how they exerted their influence. Again both CAD and CAM operators emphasised responses (b), through occasional meetings; and (d), through informal/ad hoc discussions.

Unfortunately, responses to Q-62 through Q-64 were very inconsistent. These questions attempted to determine the popularity and effectiveness of implementation teams. Individuals who responded to option (a) of Q-61 were asked to complete these questions. Five of twenty-eight CAD operators and seven of twenty-six CAM operators completed Q-62 through Q-64. The five CAD operators were dispersed through three of the six companies which had implemented design equipment. The seven CAM operators were from seven different organizations. Inter-rater reliability was low with respondents from any individual organization

both completing and skipping questions Q-62 through Q-64. The wording of option (a) of Q-61 is suspected of being the cause of this inconsistency. In option (a) respondents were asked to complete Q-62 through Q-64 if either they had been members of an implementation team or if they had been consulted by a team member. The researcher had assumed that all operators would have at least been consulted if a team had existed and therefore option (a), as it is worded, would have effectively captured all instances where an implementation team had been used. In fact, what appears to have been more likely is that most operators were not team members, were never consulted and, thus, skipped Q-62 through Q-64 even though another respondent from the same organization had indicated that a team had in fact existed.

Of the five CAD and seven CAM operators who completed Q-62 through Q-64, most rated their implementation teams high in terms of effectiveness. It should be noted, however, that all of these individuals had either been team members or had been consulted by a team member. It is difficult to speculate how the majority of other operators, those who had not been represented through a team, would have rated their team's effectiveness. They well may have rated their teams highly. This would have helped to explain the high implementation success scores despite individually low scores on participation.

8.3.1.3 HYPOTHESIS #3: Impact of Top Management Support

Similar to the total end user participation variable, the degree of association between "total top management support" and "total implementation success" was assessed using the Spearman rank correlation coefficient. The hypothesis tested was:

HO-3: There is no correlation between total top management support and total implementation success.

Results of this 2-tailed test and other relevant data are presented in Table 9. Median scores on "total top management support" are based on scale values running from one to five. For CAD operators, t calculated exceeds t critical of 1.706 at $\alpha=0.10$. For CAM operators, t calculated exceeds t critical of 1.711 at $\alpha=0.10$.

**TABLE 9: RESULTS OF THE HYPOTHESIS TEST
FOR THE TOTAL TOP MANAGEMENT SUPPORT VARIABLE**

Type of Respondent	Median Score on "Total Top Management Support"	Spearman Correlation Coefficient (r)	t calculated
CAD Operators	3.13	0.43	2.44*
CAM Operators	3.88	0.48	2.66**
* significant at $\alpha=0.05$ ** significant at $\alpha=0.01$			

The null hypothesis is rejected for both the design and manufacturing environments. The positive Spearman rank correlation coefficients r suggest that top management support has a positive influence upon operators' perceptions of implementation success, this relationship being slightly stronger in the manufacturing environment.

Spearman correlation coefficients between the individual items in top management support and implementation success are presented in Table 10 on page 47. Several results are of note. Firstly, Q-29, the extent to which top management support was maintained throughout the implementation effort, was positively associated with implementation success, although, for CAM operators only. Secondly, top management's clear explanation of the significance of the new technology, Q-33, and their encouragement of cooperation between affected organizational groups, Q-36, were positively associated with implementation success for CAD operators. The impact of Q-33 and Q-36 in the manufacturing environment, however, was not nearly as large.

TABLE 10: IMPACT OF TOP MANAGEMENT SUPPORT

TOP MANAGEMENT SUPPORT	CAD/CAM IMPLEMENTATION SUCCESS									
	Q-70) Incorporate ^a		Q-71) Used ^a		Q-72) Success ^a		Q-73) Tasks ^a		Q-74) Decrease ^a	
	CAD	CAM	CAD	CAM	CAD	CAM	CAD	CAM	CAD	CAM
Q-29) Maintained		0.41		0.43						0.34
Q-30) Pressured ^b				0.34						
Q-31) Promoted	0.41									
Q-32) Provided				0.39						
Q-33) Explained		0.54	0.35		0.46		0.47		0.39	
Q-34) Reneged				0.44						0.44
Q-35) Specified				0.51						
Q-36) Encouraged	0.37	0.35		0.49	0.44		0.45		0.37	

The table shows selected Spearman rank order correlation coefficients for pairs of items from the independent and dependent variables. All of the coefficients displayed above are significant at $\alpha=0.10$. Coefficients not included are too small or negative.

^a Same as Q-4 to Q-8 in the questionnaire for managers. Appendix B.

^b Was recorded.

Top management's provision of resources for the implementation effort, Q-32, was not very meaningful for either CAD or CAM operators. This unexpected finding may be a result of operators perceiving middle, not top, management as the provider of resources. Finally, six of the eight items in top management support were positively associated with CAM system use. None of these six, somewhat surprisingly, were meaningful in the design environment.

Data analysis suggests that top management support has a positive impact upon implementation success in both the design and manufacturing environments although meaningful manifestations of this support are different for CAD and CAM operators. Top management's clear explanation of the significance of the new technology and encouragement of cooperation between parties affected by the implementation effort were meaningful to designers. The maintenance of top management support throughout the implementation effort was meaningful to CAM operators although just about any manifestation of top management support stimulated use of the new technology amongst these people as well.

8.3.1.4 HYPOTHESIS #4: Impact of Training

Several noteworthy observations can be drawn from the examination of the "Effectiveness of Training" variable. Only 9 of 28 CAD operator respondents (32%) indicated that they had received "formal training" paid for by their company. In contrast, 19 of 26 CAM operators (73%) indicated that they had received such training. Furthermore, as displayed in Table 11, across all eight items which constituted the measurement of the "Effectiveness of Training" variable, CAM operators tended to rate the quality and quantity of their training higher than that received by their colleagues in the design department. The training received by these machine

operators, however, was still only satisfactory as the median score for most of the eight items was near three or below on a five point scale.

TABLE 11: COMPARISON OF CAD OPERATORS TO CAM OPERATORS REGARDING EFFECTIVENESS OF TRAINING

Item	Median Response of CAD Operators ^a	Median Response of CAM Operators ^b
The training I received was appropriate, given the specific tasks which I typically perform in my job.....	2.0	3.0
I received a sufficient amount of training..	3.0	3.0
The provider of the training had a very good knowledge of my specific needs.....	2.0	3.0
The scheduling of the training session(s) relative to the timing of the CAD/CAM implementation effort maximized the potential for effective learning.....	3.0	3.0
Manuals provided as part of the training program were very useful.....	3.0	3.0
A sufficient number of operating level personnel were provided with training.....	3.0	3.0
Most of my expertise with the system was gained from training sessions.....	1.0	2.0
The method(s) of instruction was (were) very effective (ie. use of video, "hands-on" practice sessions, lectures, etc.).....	2.0	3.0

^a N = 9.

^b N = 19.

^c Responses indicated on 5-point Likert-type scales; 1 = Strongly Disagree, 5 = Strongly Agree.

The disparity in the amount of training received by designers and machine operators should be considered in light of the existing skill levels of these employees. As discussed in Section 8.3.3.2, CAD operators' skill with similar technologies was considerably higher than that of machine operators. It may thus be inappropriate to conclude that CAD managers are guilty of not providing sufficient training to their employees. Indeed, it may not have been necessary to provide training to all twenty-eight designers.

Methods of instruction used for CAD operators included lectures and "hands-on" practice sessions lead by an instructor. For the latter method, complaints of too many students being forced to crowd around a single terminal were noted. Another complaint regarded the timing of training which occurred a full four months before equipment installation at one of the sites. Similarly, CAM operators most frequently noted lectures and "hands-on" practice sessions as the methods of training used. Of note is the experience of one operator who commented quite favourably upon the use of exercises on a machine control panel which was attached to a simulated machine. Two other operators from another organization commented favourably about the six weeks of dedicated time which was allotted for familiarization with the new equipment after it had been installed. During this period their mandate was to learn the equipment. They were rarely burdened with actual production jobs. Finally, CAM respondents from two of the sites complained of the timing of training which was received several months after equipment installation.

Tests of correlation between "total effectiveness of training" and "total implementation success", as perceived by operators, were done using Spearman's rank correlation coefficient (r). For CAD operators ($N = 9$), t critical is 1.895 at $\alpha = 0.10$. For CAM operators ($N = 19$),

t critical is 1.74 at $\alpha=0.10$. The hypothesis tested was:

HO-4a: There is no correlation between total effectiveness of training and total implementation success.

Results of the test and other relevant data are presented in Table 12. Median scores on "total effectiveness of training" are based on scale values running from one to five. For CAD operators, t calculated is less than t critical at $\alpha=0.10$ thus the null hypothesis cannot be rejected. For CAM operators, however, t calculated exceeds t critical at $\alpha=0.10$ and the null hypothesis is rejected. This result, in conjunction with the large positive Spearman coefficient r , suggests that more effective training does improve implementation success in the manufacturing environment.

**TABLE 12: RESULTS OF THE HYPOTHESIS TEST
FOR THE TOTAL EFFECTIVENESS OF TRAINING VARIABLE**

Type of Respondent	Median Score on "Total Effect. of Training"	Spearman Correlation Coefficient (r)	t calculated
CAD Operators	2.31	0.21	0.56
CAM Operators	3.13	0.48	2.26*
* significant at $\alpha=0.05$			

The lack of any significant correlation for CAD operators may follow from the relatively ineffective training they received. The small sample size, as well, may have contributed to this finding.

Spearman rank order correlation coefficients between the eight items which make up the effectiveness of training construct and the five items which constitute implementation success

are presented in Table 13. Not surprisingly, considerably more significant and positive coefficients were produced for the manufacturing function. Four of the eight items which constitute the effectiveness of training variable were significantly and positively associated with CAM utilization, Q-71. Also, the scheduling of training relative to the timing of the implementation effort, Q-20, and the provision of training to a sufficient number of operating level personnel, Q-23, are positively correlated with items in implementation success for CAM operators.

Given the low number of CAD operators who received training, it was felt that further analysis, incorporating all twenty-eight designer respondents, should be done on this independent variable. Similar to the analysis for the technology champion variable, training was also examined as a dichotomous, yes/no, variable using the Mann-Whitney test. Here the impact of the provision of training upon "total implementation success" was scrutinized, for CAD operators only. The null hypothesis was:

HO-4b: There is no difference in total implementation success between CAD operators who did and did not receive training.

TABLE 13: IMPACT OF TRAINING

EFFECTIVENESS OF TRAINING	CAD/CAM IMPLEMENTATION SUCCESS									
	Q-70) Incorporate		Q-71) Used		Q-72) Success		Q-73) Tasks		Q-74) Decrease	
	CAD	CAM	CAD	CAM	CAD	CAM	CAD	CAM	CAD	CAM
Q-17) Appropriate		0.55		0.75						
Q-18) Amount				0.46						
Q-19) Good Provider				0.65						
Q-20) Scheduling								0.40	0.67	0.55
Q-22) Useful Manuals										
Q-23) Sufficient #		0.65		0.57						0.44
Q-24) Expertise										
Q-25) Methods of Instr.										

The table shows selected Spearman rank order correlation coefficients for pairs of items from the independent and dependent variables. All of the coefficients displayed above are significant at $\alpha=0.10$. Coefficients not included are too small or negative.

The probability level associated with the Z score produced by this 2-tailed test and other relevant data are presented in Table 14. Given that this level is greater than $\alpha=0.10$, the null hypothesis cannot be rejected. Results suggest that the reception of training by CAD operators has little influence upon their perception of total implementation success. This is undoubtedly due to the relatively ineffective training they received, as indicated previously.

TABLE 14: RESULTS OF THE MANN-WHITNEY TEST FOR THE TRAINING, YES/NO, VARIABLE

CAD Operators Who Received Training		CAD Operators Who Did Not Receive Training		Probability Level From Z Score
N	Median Score on "Total Success"	N	Median Score on "Total Success"	
N = 9	3.6	N = 19	3.6	0.79

8.3.1.5 HYPOTHESIS #5: Impact of Lateral Support

The influence of "total lateral support" upon "total implementation success" was assessed using the Spearman rank correlation coefficient. The hypothesis tested was:

HO-5: There is no correlation between total lateral support and total implementation success.

Results of this 2-tailed test are presented in Table 15. Median scores on "total lateral support" are based on scales running from one to five. For CAD operators, t calculated does not exceed t critical of 1.706 at $\alpha=0.10$. For CAM operators, t calculated does not quite exceed t critical of 1.711 at $\alpha=0.10$. Thus, for both designers and machine operators, the null

hypothesis cannot be rejected suggesting that lateral support does not influence operators' perceptions of implementation success.

**TABLE 15: RESULTS OF THE HYPOTHESIS
TEST FOR THE TOTAL LATERAL SUPPORT VARIABLE**

Type of Respondent	Median Score on "Total Lateral Support"	Spearman Correlation Coefficient (<i>r</i>)	<i>t</i> calculated
CAD Operators	3.2	0.19	0.96
CAM Operators	3.6	0.31	1.60

Further analysis of the association between individual items in lateral support and implementation success is presented in Table 16 on the next page. Of note, is the congregation of positive and significant correlation coefficients in items Q-70 and Q-72. This was the case for both CAD and CAM operators. Statements Q-70 and Q-72, respectively, captured the extent to which the equipment had been successfully incorporated into the ongoing work activities of the organization and the extent to which the implementation was a success. The clustering effect around these two items was more pronounced in the design environment.

Despite the high reliability of the lateral support variable, it should probably be refined further as it is likely that more dimensions of it exist. More work regarding the exact definition and measurement of this construct is recommended for future study. The researcher still advocates the importance of considering the impact of new technologies upon lateral groups in the organization. Sufficient item-by-item correlations exist to warrant this assertion, despite the lack of correlation at the "total" level.

TABLE 16: IMPACT OF LATERAL SUPPORT

LATERAL SUPPORT	CAD/CAM IMPLEMENTATION SUCCESS									
	Q-70) Incorporate		Q-71) Used		Q-72) Success		Q-73) Tasks		Q-74) Decrease	
	CAD	CAM	CAD	CAM	CAD	CAM	CAD	CAM	CAD	CAM
Q-65) Cooperated	0.45	0.37				0.39				
Q-66) Committed	0.45	0.45			0.43					0.39
Q-67) Provided Info.	0.48				0.38	0.38	0.36			
Q-68) Communication	0.45				0.46					
Q-69) Collaborated							0.36			

The table shows selected Spearman rank order correlation coefficients for pairs of items from the independent and dependent variables. All of the coefficients displayed above are significant at $\alpha=0.10$. Coefficients not included are too small or negative.

8.3.2 CHARACTERISTICS OF THE SYSTEM

8.3.2.1 HYPOTHESES #6 AND #7: Impact of Usefulness and Ease of Use

The influence of system "total usefulness" and "total ease of use" upon "total implementation success" was assessed using the Spearman rank correlation coefficient.

For system usefulness, the hypothesis tested was:

HO-6: There is no correlation between total system usefulness and total implementation success.

Results of the test and other relevant data are presented in Table 17. Median scores on total system usefulness are based on scales running from one to five. For CAD operators, t calculated exceeds t critical of 1.706 at $\alpha=0.10$. For CAM operators, t calculated exceeds t critical of 1.711 at $\alpha=0.10$.

TABLE 17: RESULTS OF THE HYPOTHESIS TEST FOR THE TOTAL SYSTEM USEFULNESS VARIABLE

Type of Respondent	Median Score on "Total Usefulness"	Spearman Correlation Coefficient (r)	t calculated
CAD Operators	4.1	0.49	2.84**
CAM Operators	4.3	0.42	2.25*
* significant at $\alpha=0.05$ ** significant at $\alpha=0.01$			

Results from Table 17 necessitate the rejection of the null hypothesis. In addition, the positive correlation coefficients imply that greater system usefulness will positively influence implementation success, this relationship being stronger in the design environment.

For system ease of use, the hypothesis tested was:

HO-7: There is no correlation between total system ease of use and total implementation success.

Results of the test are presented in Table 18. For CAD operators, t calculated exceeds t critical of 1.706 at $\alpha=0.10$. For CAM operators, t calculated does not exceed t critical of 1.711 at $\alpha=0.10$.

**TABLE 18: RESULTS OF THE HYPOTHESIS
TEST FOR THE TOTAL SYSTEM EASE OF USE VARIABLE**

Type of Respondent	Median Score on "Total Ease of Use"	Spearman Correlation Coefficient (r)	t calculated
CAD Operators	3.25	0.56	3.42**
CAM Operators	3.5	0.19	0.96
** significant at $\alpha=0.01$			

For designers, the null hypothesis is rejected. The large and positive coefficient r suggests that greater ease of use has a positive influence upon their perception of implementation success. Surprisingly, for machine operators, the null hypothesis cannot be rejected implying that ease of use of shop floor equipment does not influence implementation success.

Spearman rank order correlation coefficients between items in the usefulness and implementation success variables and the ease of use and implementation success variables are presented in Tables 19 and 20, respectively. For designers only, results suggest that system usefulness and ease of use strongly influence the number of new tasks which the equipment allows, Q-73, and the decrease in the amount of time which it normally takes to do a given job,

TABLE 19: IMPACT OF USEFULNESS OF THE EQUIPMENT

EQUIPMENT USEFULNESS	CAD/CAM IMPLEMENTATION SUCCESS									
	Q-70) Incorporate		Q-71) Used		Q-72) Success		Q-73) Tasks		Q-74) Decrease	
	CAD	CAM	CAD	CAM	CAD	CAM	CAD	CAM	CAD	CAM
Q-1) Enabled		0.34	0.38		0.52		0.43		0.47	
Q-2) Improved					0.40		0.35		0.41	
Q-3) Increased					0.48		0.44		0.51	
Q-4) Enhanced										
Q-5) Easier					0.46	0.34			0.43	
Q-6) Useful		0.47			0.38	0.34	0.45		0.49	

The table shows selected Spearman rank order correlation coefficients for pairs of items from the independent and dependent variables. All of the coefficients displayed above are significant at $\alpha=0.10$. Coefficients not included are too small or negative.

TABLE 20: IMPACT OF EASE OF USE OF THE EQUIPMENT

EQUIPMENT EASE OF USE	CAD/CAM IMPLEMENTATION SUCCESS									
	Q-70) Incorporate		Q-71) Used		Q-72) Success		Q-73) Tasks		Q-74) Decrease	
	CAD	CAM	CAD	CAM	CAD	CAM	CAD	CAM	CAD	CAM
Q-7) Learning							0.32			
Q-8) To get					0.34		0.51		0.60	
Q-9) Interaction			0.38							
Q-10) Flexible			0.47				0.43		0.42	
Q-11) Become skillful		0.35	0.36				0.59		0.36	
Q-12) Easy to use		0.39				0.37	0.37		0.44	

The table shows selected Spearman rank order correlation coefficients for pairs of items from the independent and dependent variables. All of the coefficients displayed above are significant at $\alpha=0.10$. Coefficients not included are too small or negative.

Q-74. As well, results suggest that system usefulness influences the degree to which the implementation effort was a success, Q-72, and that system ease of use influences the degree to which the system is used, Q-71. Again, these results are for the design environment only.

8.3.3 CHARACTERISTICS OF THE END USER

8.3.3.1 HYPOTHESIS #8: Impact of User Age

Summary information regarding the ages of CAD and CAM operators is provided in Table 21. As can be seen, CAM operators tended to be slightly younger.

TABLE 21: COMPARISON OF CAD OPERATOR AGE TO CAM OPERATOR AGE

Type of Respondent	Minimum Age	Maximum Age	Median Age
CAD Operators	26	55	34.5
CAM Operators	22	45	32

"Age" was treated as a dichotomous variable with categories ≤ 33 and > 33 . It was not possible to delineate operators under forty years of age from those forty years of age and older, as done by Levi et al (1992) and Webster (1992), because too few respondents would have been included in the latter category. Similarly, exploration of alternative categories of age always produced at least one category, either on the CAD or CAM side, with too few respondents to permit meaningful statistical analysis. By using the threshold of thirty-three years, relatively equal numbers of operators fall into each age category and a basis of comparison between CAD and CAM operators is maintained.

Similar to the technology champion and training variables, the impact of operator age

upon total implementation success was examined using the Mann-Whitney test. The hypothesis was:

HO-8: There is no difference in total implementation success between respondents less than or equal to 33 years of age and those older than 33.

Probability levels associated with Z scores produced by this 2-tailed test and other relevant data are presented in Table 22. Levels greater than the preset α of 0.10 lead to the null hypothesis not being rejected. Results, thus, suggest that operator age has no impact upon operators' perceptions of total implementation success, in both the design and manufacturing environments.

TABLE 22: RESULTS OF THE MANN-WHITNEY TEST FOR THE AGE VARIABLE

Type of Respondent	Age $\leq$ 33		Age $>$ 33		Probability Level From Z Score
	N	Median Score on "Total Success"	N	Median Score on "Total Success"	
CAD Operators	N = 12	3.7	N = 16	3.6	0.74
CAM Operators	N = 16	4.3	N = 10	4.0	0.15

8.3.3.2 HYPOTHESIS #9: Impact of Breadth of User's Skills With Similar Technologies

As indicated in Table 23 on the next page, CAD operators were more skilled with design technologies than the machine operators were with shop floor equipment, at the time of implementation. This may help to explain the differences in the amount of training received by CAD and CAM operators, as discussed earlier. The mediocre scores of machine operators are disappointing and, hopefully, not the norm in Canadian manufacturing.

**TABLE 23: MEDIAN SCORES TO ITEMS IN THE
SKILL WITH SIMILAR TECHNOLOGIES VARIABLE**

Item	Median Score for CAD Operators	Median Score for CAM Operators
At the time the specified investment in CAD/CAM technology was implemented into the organization...		
Q-13)...my skill level with this type of equipment was...	3.0	1.5
Q-14)...my skill level with other, similar types of equipment was...	4.0	3.0
Q-15)...my experience with computerized equipment of any kind was...	4.0	3.0

The influence of "total skill with similar technologies" upon "total implementation success" was assessed using the Spearman rank correlation coefficient. The hypothesis was:

HO-9: There is no correlation between total skill with similar technologies and total implementation success.

Results of this 2-tailed test and other relevant data are presented in Table 24. Median scores on total skill with similar technologies are based on scales running from one to five. For CAD operators, t calculated does not exceed t critical of 1.706 at $\alpha=0.10$. Similarly, for CAM operators, t calculated does not exceed t critical of 1.711 at $\alpha=0.10$.

**TABLE 24: RESULTS OF THE HYPOTHESIS
TEST FOR THE TOTAL SKILL WITH SIMILAR TECHNOLOGIES VARIABLE**

Type of Respondent	Median Score on "Total Skill With Similar Technologies"	Spearman Correlation Coefficient (<i>r</i>)	<i>t</i> calculated
CAD Operators	3.33	0.21	1.08
CAM Operators	2.50	0.05	0.26

The null hypothesis cannot be rejected for either designers or machine operators suggesting that skill with similar technologies does not influence implementation success, as perceived by these people.

In addition, the Spearman rank order test produced no significant and positive correlation coefficients between the three items which constitute this independent variable and the five items which make up implementation success. This was found in both the design and manufacturing environments. Like the results for some of the other independent variables, the findings for skill with similar technologies were unexpected.

Results of the data analysis thus far are summarized in Table 25. Of note are the total top management support, total training, total usefulness, and total ease of use variables. The influence of each upon operators' perceptions of total implementation success differed between the design and manufacturing environments. It is reiterated that, in some cases, significant and positive item-by-item correlations were produced even though there was no such correlation between the "total" versions of the dependent variable and the independent variable of interest. This phenomenon, however, was almost exclusively limited to the results for lateral support.

**TABLE 25: RESULTS OF THE SPEARMAN
AND MANN-WHITNEY TESTS OF HYPOTHESES**

Hypothesis #	Independent Variable	CAD Operators	CAM Operators
HO-1a, HO-1b	Technology Champion	No Support	No Support
HO-2	Total End User Participation	No Support	No Support
HO-3	Total Top Management Support	Some Support	Strong Support
HO-4a, HO-4b	Total Training	No Support	Strong Support
HO-5	Total Lateral Support	No Support	No Support
HO-6	Total Usefulness	Strong Support	Some Support
HO-7	Total Ease of Use	Strong Support	No Support
HO-8	End User Age	No Support	No Support
HO-9	Total Skill With Similar Technologies	No Support	No Support

8.4 FURTHER ANALYSIS OF NON-SIGNIFICANT VARIABLES

The large number of insignificant findings prompted a search for other variables which may impact operators' perceptions of CAD and CAM implementation success and/or influence the relationship between the independent, non-significant variables and the dependent variable. This investigation was done separately for the design and manufacturing functions. Organizational size and degree of experience with CAD and CAM were scrutinized.

Organizational size, as measured by the number of employees, was first run in a simple linear regression against total implementation success. The explanatory power of this single independent variable was minute. Organizational size was then run in a multiple regression with all of the other non-significant variables for the design and manufacturing sides respectively.

Again, the explanatory power of the model and the incremental contribution of the independent variables remained negligible.

Organizational experience was assessed in almost the same manner. Given that only managers were asked to comment upon the extent of their organization's experience with CAD and CAM, some assumptions and manipulations of data were required. From Table 1, on a site-by-site basis, the median degree of experience, as perceived by managers, was assigned to every operator. For example, at Site 1, the degree of experience indicated is the median score of four managers. This score was allotted to each of the eight operators at this site. It is noted as a limitation of this analysis that this procedure may have introduced distortion as a small number of median scores on degree of experience were distributed over many operators. It is likely that this distorting effect was far less significant for CAM operators because the ratio of managers to operators was much higher and because a much larger proportion of the organizations which implemented CAM had only one manager respondent anyway.

Experience with CAD/CAM was run in a multiple regression with those independent variables which had previously been proven to be non-significant. The incremental contribution of these independent variables was not significant.

For interest's sake, a test of correlation between each of the non-significant variables and total implementation success was done for the two least experienced organizations only, Sites 13 and 19. It was thought that perhaps the non-significant variables were meaningful in these types of companies. No significant and positive correlation coefficients were produced.

Finally, no significant and positive correlation coefficients were produced when the operator scores on the non-significant variables were correlated with the managers' scores on

implementation success or when the tests were run using the organization as the unit of analysis.

8.5 HIERARCHICAL REGRESSION

Further analysis was done using hierarchical regression. Given the differences in the impact of the independent variables between CAD and CAM operators, this was done separately for the two types of respondents. The order of entry of independent variables into the regression attempted to isolate the impact of individual organizational characteristics after attributes of the system had been controlled for. Furthermore, within the "system" and "organizational" categories independent variables were ranked based upon the size of the Spearman rank correlation coefficient r produced in earlier analyses.

The decision as to which independent variables to include was again guided by the results of the previous tests of hypotheses. Only those variables which were proven to influence, or nevertheless strongly suspected of influencing, operators' perceptions of total implementation success were included. This avoidance of the less meaningful variables is congruent with the advice of Norusis and SPSS Inc. (1993a). For both CAD and CAM operators, the two "end user characteristics" were not included neither were the "technology champion" and "total end user participation" variables. For CAD respondents only, "total training" and "total lateral support" were also dropped. For CAM respondents, "total ease of use" was dropped although "total lateral support" was included given its relatively high correlation coefficient, $r = 0.31$. The inclusion of three and four independent variables in the CAD and CAM data sets, respectively, falls within the threshold "bare minimum" of five cases per independent variable demanded by Tabachnick and Fidell (1989).

Results of the hierarchical regression for the CAD data set are presented in Table 26 on page 70. The partial F test was used to assess the incremental impact of each independent variable as it was entered into the regression, this impact being above and beyond that of the independent variable(s) already in the equation. The test statistic, F_{change} , was used. It is calculated as follows,

$$F_{change} = \frac{\Delta R^2 (N-p-1)}{q(1-R^2)}$$

where N is the number of cases in the equation, p is the total number of independent variables in the equation, and q is the number of variables entered at each step. The significance of F_{change} is obtained from the F distribution with q and $N-p-1$ degrees of freedom.

The hypotheses tested were:

$$\begin{aligned} H_0: \Delta R^2_{pop} &= 0 \\ H_1: \Delta R^2_{pop} &> 0 \end{aligned}$$

For the CAD data set, the incremental impact of the total ease of use and total top management support variables is significant. Of note is the insignificant change in R^2 when total usefulness is entered, this after total ease of use has already been included. Nevertheless, throughout the regression, as more variables are added, both R^2 and adjusted R^2 continue to increase implying that the "goodness of fit" of the model is improving. An F test, to determine how well the final model fits the data, was also conducted. Here the F statistic,

$$F = \frac{\text{mean square regression}}{\text{mean square residual}}$$

with p and $N-p-1$ degrees of freedom was calculated. And the following hypotheses were tested:

$$\begin{aligned} H_0: R^2_{\text{per}} &= 0 \\ H_1: R^2_{\text{per}} &> 0 \end{aligned}$$

For the CAD data, $F = 7.0$. This was significant at $\alpha=0.01$. The regression model fits the data quite well, explaining 47% of the variation in operators' perceptions of total CAD implementation success - adjusted $R^2 = 0.4$.

Results of the hierarchical regression for CAM operators are presented in Table 27 on page 71. The F_{change} and F tests were repeated. The influence of total usefulness and total training, at their respective stages in the regression, was significant, although only at $\alpha=0.10$. The incremental impact of total top management support and total lateral support were not significant although adjusted R^2 continued to increase when they were entered. The test for the goodness of fit of the model produced $F = 3.12$, significant at $\alpha=0.05$. The model fits the data reasonably well, explaining 37% of the variation in total CAM implementation success, as perceived by machine operators. Adjusted $R^2 = 0.25$.

In comparing the results of Tables 26 and 27, two findings are of note. The first is the difference in importance of system characteristics which explained a far greater proportion of the variation in implementation success for CAD operators. Secondly, is the inclusion of top management support which was the only organizational context variable considered in both the design and manufacturing environments. For CAD operators especially, top management support contributed significantly to the hierarchical regression even after system characteristics had been controlled for.

**TABLE 26: HIERARCHICAL REGRESSION OF
SELECTED INDEPENDENT VARIABLES ON "TOTAL
IMPLEMENTATION SUCCESS"; CAD OPERATORS ONLY**

	BLOCK #	BETA	BETA	BETA
System Characteristics	1) Total Ease of Use	0.56	0.40	0.41
	2) Total Usefulness		0.27	0.21
Organizational Context Characteristics	3) Total Top Mngt. Support			0.33
	R ² =	0.31	0.36	0.47
	ΔR^2 =	0.31**	0.05	0.11*
	F _{change} =	11.77	1.94	4.74
	d.f. =	1,26	1,25	1,24
Adjusted R ² =		0.29	0.31	0.40

** : significant at $\alpha=0.05$
*** : significant at $\alpha=0.01$

**TABLE 27: HIERARCHICAL REGRESSION OF
SELECTED INDEPENDENT VARIABLES ON "TOTAL
IMPLEMENTATION SUCCESS"; CAM OPERATORS ONLY**

	BLOCK #	BETA	BETA	BETA	BETA
System Characteristics	1) Total Usefulness	0.34	0.29	0.31	0.28
Organizational Context Characteristics	2) Total Training		0.34	0.13	0.19
	3) Total Top Mngt. Support			0.35	0.32
	4) Total Lateral Support				0.27
	$R^2 =$ $\Delta R^2 =$ $F_{\text{change}} =$ $d.f. =$	0.11 0.11* 3.07 1,24	0.22 0.11* 3.26 1,23	0.30 0.08 2.53 1,22	0.37 0.07 2.31 1,21
Adjusted $R^2 =$		0.08	0.16	0.21	0.25

"*": significant at $\alpha=0.10$

9.0 CONCLUSIONS

In summary, the impact of nine independent variables upon operators' perceptions of implementation success was examined, for CAD and CAM data separately. Except for operator age, these variables were hypothesized to positively influence success. Results were not entirely congruent with what had been predicted nor were findings identical for designers and machine operators. On the design side, the results of Spearman tests of correlation suggested that equipment usefulness and ease of use, and top management support significantly influenced CAD operators' perceptions of implementation success. In manufacturing, equipment usefulness, training, and top management support similarly influenced machine operators' perceptions of implementation success. Also in some cases, particularly with lateral support, a number of significant item-by-item correlation coefficients were produced, even though no correlation was found at the "total" level.

The researcher reiterates that this investigation focussed on the implementation of CAD and CAM additions to CAD/CAM systems. This work, in part, was based on older literature from when the adoption and implementation of AMTs constituted a significantly more profound change for the organization. Beatty (1987), for example, examined the transition from manual drafting and design methods to CAD. This is a much more radical innovation than the typical implementation effort studied here. Given that most organizations today have benefited from approximately ten years of learning, it makes sense that the same independent variables may no longer be as relevant.

Other reasons why results differed from those which had been predicted include the questionable efficacy of the data collection devices, for some variables, and insufficient variation

in the dependent variable.

10.0 LIMITATIONS OF THE STUDY

Acceptance of the findings of this study must be tempered by several limitations. Although it was argued that the influence of the independent variables would be meaningful for both organizations which are first time and experienced users of CAD/CAM, this research was not able to facilitate any such comparison. The results discussed here are drawn almost exclusively from a sample of very experienced organizations. As indicated in Table 1 on page 25, managers, overall, rated their companies' experience 4.0 out of 5. In addition, the lack of variation in implementation success is suspected of having clouded the precise nature of the relationships between the independent and dependent variables.

Concerns about the generalizability of the findings of this study must be noted given that a nonprobability sampling design was used. The inclusion of companies of different sizes and from different industries and geographic locations was intended to counter this weakness.

The problem of selective recall may have existed given that respondents were asked to reflect on events which occurred up to four years prior to data collection. Furthermore, given that operating level personnel were queried about various facets of management practices it is possible that systematic bias may have entered into the study. For example, if an operator held a grudge against his/her manager, even for a completely foreign reason, this may have affected their responses on the questionnaire. Operator group cohesiveness, mentioned by both Beatty (1987) and Leonard-Barton and Kraus (1985), may also have affected responses. This describes a situation where the attitudes of operator leaders may have been adopted, to some degree, by

followers in the design and manufacturing departments. The impact of this upon respondent bias may have been magnified in instances where operators filled out their questionnaires together, during their lunch breaks, for example.

Another variation of response bias, the "halo effect", may have been a factor. This is a common weakness of cross-sectional research where information is collected, at one point in time, about events which occurred in the past. In this study, the halo effect would have encouraged operators to score the independent variables in a certain way, depending upon how successful the implementation effort was. In essence then, a situation of reverse causality would have existed.

The researcher recognizes the halo effect as a limitation of this study, however, does not feel that its impact was significant, for the following reasons. Firstly, if it had, in fact, been significant all of the independent variables, except age, would have been scored in the same way, ie. they would have had a positive and significant impact upon operators' perceptions of implementation success. Secondly, measurement of most of the independent variables was done using multi-item scales for which each item prompted responses to very specific dimensions of the theoretical construct. For example, the nine items which together measure "end user participation" focussed upon specific activities and decisions. The measurement devices used tended to be more objective and, thus, less susceptible to the "halo effect". Reliability of the multi-item measures was, almost universally, very high, as well.

A final, and perhaps most important, limitation has been drawn from the IT implementation literature. This is the effect of mandated use upon implementation success. Alavi and Joachimsthaler (1992) discuss the differences between "mandatory and voluntary

system usage" (p. 96). And Adams et al (1992) discuss voluntary and "captive use" (p. 233), the latter of which describes a situation where equipment "usage is not strictly required as part of a job" though there exists "no alternative but to use that system to effectively complete the job" (p.233). CAD and CAM technologies fall into the category of "mandatory" or "captive" use. Adams et al (1992) state that "mandatory use... has a positive impact on usage and that in situations of mandated use other factors tend to have less ability to explain the adoption and use" (p. 243). Essentially these researchers are arguing that high degrees of usage can largely be a product of: (1), the absence of any alternative means by which to complete the job; (2), management mandate; and (3), even social pressure to conform to the norms of the organization or peer group. The model examined in this research does not really consider any of these factors, thus, it is plausible that the universally high degree of implementation success found here may be, to some degree, a result of some sense of urgency or need felt by operators. These feelings may stem from a need to conform, an awareness of competitive pressures, or simply obedience to management directives. This hypothesis would shed some light on the apparent lack of influence of several key independent variables including end user participation, the involvement of an effective technology champion, and operator skill with similar technologies.

As a corollary to this issue, this study was conducted during the tail end of a severe economic recession which had caused considerable upheaval in North American manufacturing. It is reasonable to assume that this gloomy backdrop may have heightened fears of unemployment amongst operators and further encouraged their cooperation, perhaps even eagerness, to embrace new technologies in the workplace. Perhaps the paradigm of workers resisting automation was true a decade ago. This researcher argues that it is more likely today

that most workers realize the need to master AMTs to protect the competitiveness of their organization and themselves as well.

11.0 IMPLICATIONS AND ADVICE FOR MANAGERS

Managers should interpret the findings of this research cautiously. It should be remembered that the organizations examined in this study were very experienced with CAD and CAM technologies. For less experienced companies those independent variables which proved not influential here should still be given due consideration.

The improvement of training should be a priority. Recall that CAD operators rated their instruction as very poor and, for these individuals, ineffective training did not influence their perceptions of implementation success. Machine operators rated the quality of their instruction as only average. Although training did positively influence their perceptions of success, this result was probably exaggerated given the weak skills that they initially had with similar technologies. The exploration of feedback mechanisms between operator and teacher could contribute to the improvement of training. Another, more adventurous remedy would be to encourage particularly enthusiastic and competent operators to assume informal teacher's roles within the organization. Benefits of this option include that such individuals would have a better understanding of their colleagues' needs and of company processes and norms. Such individuals, however, may be reluctant to assume this role and/or may require some training in interpersonal skills and teaching methods.

Managers should try to dedicate more funds and time to mastering the equipment. The simple provision of free time to explore the capabilities of new technologies, unburdened by

actual jobs, would be very fruitful. As well, training should occur as close as possible to the time of equipment installation. This was a common complaint amongst both CAD and CAM operators. This advice, of course, must be tempered by the very real constraints of time and money within which companies must function.

Although the exact standing of Canadian companies, vis-a-vis that of foreign organizations, in regards to employer-provided training remains contentious¹², there appears, despite the findings of this research, to be little doubt about the relationship between investment in training and productivity. Starr's (1993) extensive longitudinal study of the investment practices of American firms and European and Japanese subsidiaries operating in the United States concluded that the Japanese affiliates consistently invested significantly more on training than their American and European counterparts. Furthermore, these investments in training, coupled with similarly large and regular investments in new technology, provided the Japanese firms with the highest productivity levels. The Japanese preference for "across-the-board rotational training" (p. 92) provided to all workers was noted as significant. American and European firms tended to provide training only to those employees who were immediately affected by new technologies. Japanese managers maintained that their emphasis on training contributed to "lower levels of turnover and lower absentee rates" (p. 92). In contrast, some American and European firms argued that training was likely to lead to higher turnover rates as better skilled workers would be motivated to seek employment elsewhere.

For CAD operators especially, consider carefully equipment usefulness and ease of use.

¹² as disputed by Freeman in his article "Myth of Poor Worker Training Attacked: Study Challenges Belief Canadian Firms Provide Less Education Than Foreign Competitors". The Globe And Mail, Tuesday, November 2, 1993, pg. A1.

If line managers are not sufficiently technologically competent to make sound judgements than consider the inclusion of operator representatives in the equipment selection process.

Demonstrate top management support to CAD and CAM operators. As discussed earlier, top management's clear explanation of the significance of the new technology, encouragement of cooperation between parties affected by the implementation effort, and maintenance of support throughout the implementation effort are all meaningful. Recall that "top management" was defined as "vice president's level and higher" thus make sure that a legitimate senior manager personally displays such support.

In regards to the concept of mandatory use, attempt to create unanimity amongst operators as to the need for change. Communicate, even stress, the competitiveness of the business environment and how continuous investments in technology must be made and mastered in order for the company to prosper. Both line and senior management could do this.

12.0 IMPLICATIONS FOR FUTURE RESEARCH

Avenues for expanding upon this study are numerous. Foremost among them should be exploration of the impact of "mandatory use" upon operators' perceptions of implementation success. Ongoing identification and examination of other variables would be a worthwhile pursuit also. Individual operator characteristics, which have been scrutinized to a much greater extent in the IT literature, include user cognitive and decision making styles. Examination of implementation in a unionized setting would be interesting. Only one of the participating companies in this study was unionized. The apparent cohesiveness of managers and operators involved lead the researcher to believe that unionization was not a factor in this specific setting.

The champion who was unanimously identified was, in fact, a union member. Finally, "lateral support" could be refined further. Despite the high inter-item reliability of the measure used in this study, its definition should be narrowed.

13.0 CLOSING STATEMENTS

This research has attempted, in part, to integrate the managerial themes which prevail in the AMT implementation literature and the user characteristics more commonly examined in the IT literature. It is appropriate, in summary, to reiterate the significance of technological change, the impetus for embarking on this study. Adler (1990a) argues that rare, isolated occurrences of significant technological change in the workplace are a thing of the past. Soon, if not already, companies will need to be able to accommodate an "acceleration of automation". This expression describes a snowball effect where "the higher the level of automation, the greater the opportunity for further automation" (p. 206), as well as the likelihood that further automation will occur. The organizational and managerial implications of this are, of course, profound. Adler argues that "organizations will need to develop the ability to aggressively pursue constant change" (p.207) in order to overcome the challenges of accelerating automation. He offers that the adoption of a "more pro-active learning orientation" (p.213) should be a priority. This research, it is hoped, has contributed to that learning.

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APPENDIX A: Example of Questionnaire For Operating Level Personnel

CAD/CAM IMPLEMENTATION SURVEY

**School of Business
Carleton University**

SECTION A

The following statements express various opinions about CAD/CAM technologies. Please respond to these statements with respect to the specific investment made in CAD/CAM which was identified in the introductory letter which accompanied this questionnaire. To indicate your response please circle only one number on the scale to the right of each of the statements.

THE CAD/CAM TECHNOLOGY...	<u>STRONGLY DISAGREE</u>					<u>STRONGLY AGREE</u>				
Q-1) ... has enabled me to accomplish tasks more quickly.....	1	2	3	4	5					
Q-2) ... has improved my job performance.....	1	2	3	4	5					
Q-3) ... has increased my productivity.....	1	2	3	4	5					
Q-4) ... has enhanced my effectiveness on the job.....	1	2	3	4	5					
Q-5) ... has made it easier for me to do my job.....	1	2	3	4	5					
Q-6) ... has been useful in my job.....	1	2	3	4	5					
 FURTHERMORE:										
Q-7) Learning to operate the CAD/CAM system has been easy for me.....	1	2	3	4	5					
Q-8) I find it easy to get the system to do what I want it to do.....	1	2	3	4	5					
Q-9) My interaction with the system has been clear and understandable.....	1	2	3	4	5					
Q-10) I have found the system to be flexible to interact with.....	1	2	3	4	5					

	<u>STRONGLY DISAGREE</u>			<u>STRONGLY AGREE</u>		
Q-11) It has been easy for me to become skillful at using the system.....	1	2	3	4	5	
Q-12) I have found the system easy to use.....	1	2	3	4	5	

AND:

AT THE TIME THE SPECIFIED
INVESTMENT IN CAD/CAM TECHNOLOGY
WAS IMPLEMENTED INTO THE
ORGANIZATION...

	<u>VERY LOW</u>			<u>VERY HIGH</u>		
Q-13) ... my skill level with this type of equipment was.....	1	2	3	4	5	
Q-14) ... my skill level with other, similar types of equipment was.....	1	2	3	4	5	
Q-15) ... my experience with computerized equipment of any kind was.....	1	2	3	4	5	

SECTION B

This section consists of questions concerning training you may have received.

Q-16) There are many ways by which an individual can become proficient at using a certain type of equipment. Proficiency can be achieved by teaching oneself, by learning from one's colleagues on the job, or by more "formal" means, for example, via recognized seminars, workshops, or credit courses. Did you receive formal training, paid for by your company, from the CAD/CAM vendor, a recognized consultant or institution, or a training department internal to your organization ? (please circle 1 or 2)

If you did receive formal training please go to Q-17 on page A4.

← 1 YES
2 NO →

If you did **NOT** receive formal training please go to Q-27 on page A5.

Each of the following statements pertains to the formal training which you received. Please circle the one number which indicates your response to each of the statements.

	<u>STRONGLY DISAGREE</u>			<u>STRONGLY AGREE</u>		
Q-17) The training I received was appropriate, given the specific tasks which I typically perform in my job.....	1	2	3	4	5	
Q-18) I received a sufficient amount of training.....	1	2	3	4	5	
Q-19) The provider of the training had a very good knowledge of my specific needs.....	1	2	3	4	5	
Q-20) The scheduling of the training session(s) relative to the timing of the CAD/CAM implementation effort maximized the potential for effective learning.....	1	2	3	4	5	
Q-21) In relation to the timing of the implementation effort, when did training occur ? (For example, it may have occurred before, during, or after implementation. If it occurred before or after, then please state by how many weeks it actually preceded or followed implementation.)						

	<u>STRONGLY DISAGREE</u>			<u>STRONGLY AGREE</u>		
Q-22) Manuals provided as part of the training program were very useful.....	1	2	3	4	5	
Q-23) A sufficient number of operating level personnel were provided with training.....	1	2	3	4	5	
Q-24) Most of my expertise with the system was gained from training sessions.....	1	2	3	4	5	

STRONGLY
DISAGREE

STRONGLY
AGREE

Q-25, The method(s) of instruction
was (were) very effective
(ie. use of video, "hands-on"
practice sessions, lectures,
etc.).....

1 2 3 4 5

Q-26) Please describe briefly the method(s) of instruction used.

Please skip the next
2 questions and go to
Q-29 on page A6.

Q-27) How did you become proficient in the use of the equipment ?
Circle all the options below which apply.

- a) HELP FROM MY COLLEAGUES
- b) SELF-TAUGHT
- c) OTHER (please specify):

Q-28) Describe training which you would have liked to have
received through formal instruction.

SECTION C

The following statements express attitudes regarding the supportiveness of top management (ie. Vice President's level and higher) for the implementation of CAD/CAM. For each of the following statements please indicate the extent to which you agree or disagree with the feeling being expressed (circle number).

	<u>STRONGLY DISAGREE</u>			<u>STRONGLY AGREE</u>		
Q-29) Support from top management was maintained throughout the implementation effort...	1	2	3	4	5	
Q-30) Top management pressured us for immediate productivity gains using the new equipment.....	1	2	3	4	5	
Q-31) Top management worked very hard to promote the new technology within the company.....	1	2	3	4	5	
Q-32) Top management provided sufficient resources for the implementation effort (ie. money, people).....	1	2	3	4	5	
Q-33) Top management clearly explained the significance of the new technology in achieving the strategic objectives of the company...	1	2	3	4	5	
Q-34) Top management never reneged on promises which they had made.....	1	2	3	4	5	
Q-35) Top management clearly specified realistic goals for the implementation effort (ie. deadlines to be met, degree of integration to be achieved).....	1	2	3	4	5	
Q-36) Top management encouraged cooperation between the various groups which were affected by the implementation effort.....	1	2	3	4	5	

SECTION D

Q-37) Was there a specific individual who actively promoted and directed the incorporation of the new CAD/CAM technology into your organization ?

Q-38) Please indicate:

THIS INDIVIDUAL'S NAME:

THIS INDIVIDUAL'S FORMAL JOB TITLE:

THE LENGTH OF TIME THIS INDIVIDUAL HAS BEEN WITH THE COMPANY:

Below are a number of skills and traits that various people might have. For each item please indicate the extent to which the individual identified above exhibited the skill/trait.

THE INDIVIDUAL WHO ACTIVELY
PROMOTED AND DIRECTED THE
INCORPORATION OF THE NEW CAD/CAM
TECHNOLOGY WAS...

	<u>NOT</u> <u>AT ALL</u>					<u>TO A</u> <u>VERY</u> <u>GREAT</u> <u>EXTENT</u>
Q-39) ... supportive.....	1	2	3	4	5	
Q-40) ... a good listener.....	1	2	3	4	5	
Q-41) ... determined.....	1	2	3	4	5	
Q-42) ... a good project manager..	1	2	3	4	5	

THE INDIVIDUAL WHO ACTIVELY
PROMOTED AND DIRECTED THE
INCORPORATION OF THE NEW CAD/CAM
TECHNOLOGY WAS...

NOT
AT ALL

TO A
VERY
GREAT
EXTENT

Q-43) ... persuasive.....	1	2	3	4	5
Q-44) ... able to motivate others.....	1	2	3	4	5
Q-45) ... able to communicate well.....	1	2	3	4	5
Q-46) ... adept at working within the political environment of the organization.....	1	2	3	4	5

FURTHERMORE THIS INDIVIDUAL...

Q-47) ... had consistent support from top management.....	1	2	3	4	5
Q-48) ... had considerable formal authority.....	1	2	3	4	5
Q-49) ... had the respect of everyone in your organization.....	1	2	3	4	5

AND:

STRONGLY
DISAGREE

STRONGLY
AGREE

Q-50) In my opinion, the efforts of this individual contributed positively to the incorporation of the new technology into my organization.....	1	2	3	4	5
--	---	---	---	---	---

SECTION E

Typically, when new technology or equipment is brought into an organization several key decisions and activities occur. Please indicate the degree to which you personally had influence in each of the following decisions and activities. Please circle only one response for each of the following items.

<u>Decision or Activity</u>	<u>DEGREE OF</u> <u>MY INFLUENCE</u>				
	<u>NONE</u>				<u>SUBSTANTIAL</u>
Q-51) The recognition of the need to purchase the CAD/CAM equipment.....	1	2	3	4	5
Q-52) Lobbying for resources required for the purchase and implementation of the equipment.....	1	2	3	4	5
Q-53) The decision to purchase the equipment.....	1	2	3	4	5
Q-54) Selection of the equipment..	1	2	3	4	5
Q-55) The creation of the CAD/CAM implementation plan.....	1	2	3	4	5
Q-56) Installation of the equipment.....	1	2	3	4	5
Q-57) Testing of the equipment....	1	2	3	4	5
Q-58) Setting productivity standards for the equipment.....	1	2	3	4	5
Q-59) Ongoing planning for modifications/additional investments to the system.....	1	2	3	4	5

Q-60) In regards to the decisions and activities listed on the previous page what type(s) of influence did you use ? Please circle all the options listed below which apply.

- a) I RECEIVED INFORMATION
 - b) I PROVIDED INFORMATION
 - c) I PARTICIPATED IN DECISION MAKING
 - d) I EXERCISED A VETO
 - e) OTHER (please specify):
-

Q-61) How did you exert your influence in the decisions and activities listed on the previous page ? Please circle all the options below which apply.

- a) THROUGH REPRESENTATION ON A FORMAL CAD/CAM PROJECT TEAM
(ie. either through your own membership on this team or through team members consulting with you)
 - b) THROUGH OCCASIONAL MEETINGS
 - c) THROUGH INTERNAL MEMOS
 - d) THROUGH INFORMAL/AD HOC DISCUSSIONS
 - e) OTHER (please specify):
-

If your answer to Q-61 above did **NOT** include option (a) then please skip the following three questions and go to Q-65 on page A11.

Q-62) Did the formal CAD/CAM project team include any CAD users or CAM machine operators ?

- 1 YES
- 2 NO

Q-63) Were you personally a member of the CAD/CAM project team ?

- 1 YES
- 2 NO

	<u>NOT AT ALL EFFECTIVE</u>			<u>VERY EFFECTIVE</u>	
Q-64) How effective was the CAD/CAM project team in representing your concerns ?	1	2	3	4	5

SECTION F

Typically, CAD/CAM technologies affect many groups within an organization not just those which receive the technology. Such "lateral" groups could include, for example, the information systems department or other constituencies whose activities are linked to the product design and manufacturing processes. The five statements below comprise possible reactions of "lateral" groups to the efforts in your specific area to implement the new technology. Please indicate the extent to which you agree or disagree with each of the following statements.

	<u>STRONGLY DISAGREE</u>			<u>STRONGLY AGREE</u>		
Q-65) In general, lateral groups cooperated fully during the implementation effort.....	1	2	3	4	5	
Q-66) In general, lateral groups were fully committed to the implementation effort.....	1	2	3	4	5	
Q-67) In general, lateral groups gladly provided information which was required for the implementation effort.....	1	2	3	4	5	
Q-68) In general, communication with lateral groups during the implementation process was easy.....	1	2	3	4	5	
Q-69) In general, we collaborated regularly with lateral groups to develop new applications for the technology.....	1	2	3	4	5	

SECTION G

The following statements reflect opinions which individuals may have after a new technology has been brought into their organization. With specific reference to the investment in CAD/CAM which was identified in the introductory letter, please indicate the extent to which you agree or disagree with the idea being expressed in each of the following statements.

	<u>STRONGLY DISAGREE</u>			<u>STRONGLY AGREE</u>	
Q-70) CAD/CAM has been successfully incorporated into the ongoing work activities of the organization.....	1	2	3	4	5
Q-71) All elements of the system are widely used.....	1	2	3	4	5
Q-72) Overall, I think the CAD/CAM implementation was a success.....	1	2	3	4	5

FURTHERMORE, COMPARED TO WHAT WAS
ORIGINALLY PLANNED...

	<u>MUCH LESS</u>			<u>MUCH GREATER</u>	
Q-73) ...the number of new tasks which the equipment allows is.....	1	2	3	4	5
Q-74) ...the DECREASE in the amount of time which it normally takes to do a given task is.....	1	2	3	4	5
Q-75) ...the actual amount of time to implement the system was.....	1	2	3	4	5
Q-76) ...the actual cost to implement the system was....	1	2	3	4	5

SECTION H

The final few questions pertain to yourself and your company. This information is important as it allows an examination of the effects of differences between people and organizations upon CAD/CAM implementation.

Q-77) Please provide the following information:

NAME OF COMPANY

YOUR FORMAL JOB TITLE

Q-78) Please describe briefly your major responsibilities in your job.

Q-79) From where within the organization did the recommendation to make the specific investment in CAD/CAM come ? (for example, from CAD designers, CAM machine operators, mid- or senior level management ?)

Q-80) What is your age ?

_____ YEARS

PLEASE DO NOT DISCUSS THIS QUESTIONNAIRE WITH ANYONE

THANK YOU VERY MUCH FOR PARTICIPATING IN THIS SURVEY

APPENDIX B: Example of Questionnaire For Managers

CAD/CAM IMPLEMENTATION SURVEY

**School of Business
Carleton University**

The following questions pertain to your company, yourself, and the specific investment made in CAD/CAM technologies which was identified in the introductory letter and/or conversation.

Q-1) Please provide the following company information:

NAME OF COMPANY

NUMBER OF EMPLOYEES IN THE COMPANY (approximately)

ANNUAL \$ SALES OF THE COMPANY (approximately)

DESCRIBE BRIEFLY THE NATURE OF THE COMPANY'S BUSINESS

Q-2) Please provide the following personal information:

YOUR FORMAL JOB TITLE

DESCRIBE BRIEFLY YOUR MAJOR JOB RESPONSIBILITIES

Q-3) From where within the organization did the recommendation to make the specific investment in CAD/CAM come ? (eg. from CAD designers, CAM operators, mid- or senior level management)

The following statements reflect opinions which individuals may have after a new technology has been brought into their organization. For each of the following statements please indicate the extent to which you agree or disagree with the idea being expressed.

	<u>STRONGLY DISAGREE</u>			<u>STRONGLY AGREE</u>		
Q-4) The CAD/CAM system has been successfully incorporated into the ongoing work activities of the organization.....	1	2	3	4	5	
Q-5) All elements of the system are widely used.....	1	2	3	4	5	
Q-6) Overall, I think the CAD/CAM implementation was a success.....	1	2	3	4	5	

FURTHERMORE, COMPARED TO WHAT WAS
ORIGINALLY PLANNED...

	<u>MUCH LESS</u>			<u>MUCH GREATER</u>		
Q-7) ...the number of new tasks which the equipment allows is.....	1	2	3	4	5	
Q-8) ...the DECREASE in the amount of time which it normally takes to do a given task is.....	1	2	3	4	5	
Q-9) ...the actual amount of time to implement the system was.....	1	2	3	4	5	
Q-10) ...the actual cost to implement the system was....	1	2	3	4	5	

FINALLY,	<u>STRONGLY DISAGREE</u>			<u>STRONGLY AGREE</u>		
Q-11) Personally, I feel my company is very experienced with CAD/CAM technologies...	1	2	3	4	5	

THANK YOU VERY MUCH FOR PARTICIPATING IN THIS SURVEY

**APPENDIX C: Example Of Introductory Information Sheet
Which Was Faxed To Company Contact Person**

Carleton
UNIVERSITY

**School of Business
Faculty of Social Sciences**
Dunton Tower
1125 Colonel By Drive
Ottawa, Canada K1S 5B6
Tel. (613) 788-2388
Fax. (613) 788-2532 or (613) 788-4427

17 Madawaska Drive
Ottawa, Ont., K1S 3G5
Tel & Fax: (613) 236-3146
Date XXXXXXXXXXXXXXXXXXXXXXXX

Mr. XXXXXXXXXXXX
XXXX Company Ltd.
Fax: XXX-XXXX

Dear Mr. XXXXXX,

As per our discussion, I am faxing you information explaining my work along with copies of the questionnaires which I am using to collect the data.

I am pursuing research on the implementation of CAD/CAM technologies. The purpose of this work is to elucidate the concerns of operating level personnel during the implementation process. CAD/CAM users, such as mechanical designers and CNC machine operators, are asked to comment upon various organizational, personal, and equipment variables which are hypothesized to influence implementation success. Differences between the perspectives of these types of individuals will also be explored. The output of this study will provide useful guidance to organizations such that their future implementation efforts can be improved.

Data is being collected via two structured questionnaires. The larger of the two (12 pgs.) is completed by CAD/CAM operators. The smaller, two-page questionnaire is completed by managers who were responsible for the implementation effort. The larger questionnaire takes approximately twenty minutes to complete. The smaller one takes under five minutes. Both have already been administered to employees at XX Canadian companies.

I am currently identifying and soliciting the participation of Canadian companies which made a significant investment in CAD/CAM equipment between one and four years ago. I was advised by Mr. XXX XXXX to contact you.

The anonymity of individual respondents and participating organizations is guaranteed and results of the study will be made available to all participating companies.

I will telephone you within the next few days to continue our discussion. In the meantime please feel free to contact me. Thank you very much for your time.

Sincerely,

Andrew Collin

**APPENDIX D: Example Of Information
Sheet For Operator Respondents**

Carleton
UNIVERSITY

**School of Business
Faculty of Social Sciences**
Dunton Tower
1125 Colonel By Drive
Ottawa, Canada K1S 5B6
Tel: (613) 788-2388
Fax: (613) 788-2532 or (613) 788-4427

Date XXXXXXXXXXXXXXXX

Dear Sir/Ma'am,

Thank you for taking the time to complete this questionnaire. It is being used to collect data for research being done on the CAD/CAM implementation experiences of Canadian manufacturing companies. The fundamental purpose of this work is to elucidate the concerns of CAD/CAM users, including mechanical designers and CNC machine operators, during the implementation process. Research to date suggests that the full benefits of CAD/CAM technologies are not being reaped, partially because of management's limited and/or inaccurate understanding of the concerns of the individuals who are to use the equipment. This work aims to shed light on this issue.

Some of your colleagues have also been asked to complete a questionnaire. As well, CAD/CAM users from a number of other Canadian manufacturing companies are being surveyed. In order for the results of this study to truly represent the thinking of CAD/CAM users, it is important that each questionnaire be completed and returned.

The privacy of individual respondents and the organizations which they work for is of the utmost importance and the anonymity of both is guaranteed. Please note that you are NOT required to provide your name.

The questionnaire takes approximately 20 minutes to complete. Assume that all of the questions pertain only to the investment in the XXXXXXXXXX equipment which was made approximately XX years/months ago. Skip those questions which you are not able to answer. Also, feel free to contribute extra thoughts or information if you so desire.

Please do not discuss the questionnaire with anyone. Results derived from the cumulative data collected from all participating companies will be made available as soon as possible.

Thank you very much for your time.

Sincerely,

Andrew Collin

**APPENDIX E: Example Of Information
Sheet For Manager Respondents**

**School of Business
Faculty of Social Sciences**
Dunton Tower
1125 Colonel By Drive
Ottawa, Canada K1S 5B6
Tel: (613) 788-2388
Fax: (613) 788-2532 or (613) 788-4427

Date XXXXXXXXXXXX

Dear Sir/Ma'am,

Thank you for taking the time to complete this questionnaire. It is being used to collect data for research being done on the CAD/CAM implementation experiences of Canadian manufacturing companies. The fundamental purpose of this work is to elucidate the concerns of CAD/CAM users, including mechanical designers and shop floor machine operators, during the implementation process. As well, managers who were responsible for the implementation effort are asked for their input. The results of this work will provide useful guidance to organizations such that their future implementation efforts can be improved.

Some of your colleagues have also been asked to complete a questionnaire. As well, CAD/CAM managers and users from a number of other Canadian manufacturing companies are being surveyed. In order for the results of this study to be valid, it is important that each questionnaire be completed and returned.

The privacy of individual respondents and the organizations which they work for is of the utmost importance and the anonymity of both is guaranteed. Please note that you are NOT required to provide your name.

The questionnaire takes less than 5 minutes to complete. Assume that all of the questions pertain only to the investment in the XXXXXXXXX equipment which was made approximately XX years/months ago. Skip those questions which you are not able to answer. Also, feel free to contribute extra thoughts or information.

Please do not discuss the questionnaire with anyone. Results derived from the cumulative data collected from all participating companies will be made available as soon as possible.

Thank you very much for your time.

Sincerely,

Andrew Collin

END

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