Status of the Research on Technology Implementation

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The growing importance of IT, combined with the increasing investment in these technologies in organizations, makes implementation a high priority research topic. Although many studies show that IT implementation has become a topic of interest over the past two decades, most of the studies found have focused on studying IT implementation in general, and the focus has been on medium to large sized organizations.

In this paper, I will present the findings of a literature research of studies in the area of technology implementation from 1990 to 2001. Although it was of interest to review studies in the general area of IT, the objective was to find studies in the area of Advanced Manufacturing Technologies (AMT), and more specifically in the area of CAD/CAM.

Each of the studies was reviewed by using a common template for their analysis. This template includes the following items: type of IT studied, research method (case study, field study, field experiment, laboratory experiment, conceptual study or review/tutorial), sample size, organization size, implementation level (individual, work group, organization, inter-organization), research focus (success/failure, management, impact on user, issue/problem, experience, planning, process, strategy), findings and future research questions.

STATUS OF THE RESEARCH IN INFORMATION TECHNOLOGY IMPLEMENTATION FROM 1976-1995:

In 1997 Vincent Lai and Radha Mahapatra explored the intellectual development and evolution of IT implementation research through a meta-analysis of published MIS research. Their findings are based on an analysis of 71 articles on IT implementation published during the 1976-1995 period in top MIS journals. The results indicate that IT implementation research is sensitive to the evolving role of IT in organizations. They also found that there was a shift in emphasis from studying individual IT to organizational and inter-organizational IT. A summary of their findings follows:

Publication Trend: In a 5-year interval period since 1976, it appeared that IT implementation research showed a steadily increasing trend. Among the individual periodicals, MIS Quarterly, and Information Management exhibited the highest number of implementation articles, with a combined total of forty-five (63.4%) for the 20-year period under study.

Research Focus: Their analysis revealed that implementation success (46.5) and management (38.0%) were the two most explored research topics. In addition to success factors and managerial issues of IT implementation, researchers were also interested in exploring the impact of implementation on users (19.7%). Topics in this category include job characteristics, attitude, productivity enhancement, acceptance of new systems, user involvement, and resistance to change.

It is important to note that a number of these studies focused on production and operations management. An increased interest was observed in technologies such as CAD/CAM, JIT systems and flexible manufacturing.

IT Adoption Level: Organizational technologies were the most heavily researched, drawing a total of forty-three (60.56%) publications out of 71. This was followed by individual IT with sixteen articles (22.5%). Research addressing inter-organizational and group-level IT implementation both accounted for six articles (8.5%) each. More research efforts were devoted to organizational IT than any other level of IT adoption.

Research Methodology: Field study and case study were the two most popular research methods for IT implementation research. A total of 26 out of the 71 (36.6%) studies used field study as the research method. Twenty-four (33.8%) articles reported the use of case study as the research method. In general, empirical approaches were preferred to non-empirical approaches in implementation research. The results did not support the hypothesis that MIS researchers have preferred methods in conducting their implementation studies.

The case study method seemed to be used frequently in research studying IT adopted at the group as well as at organizational levels. Most of these case studies examined the designs, strategies, and implementation experiences of organizations, with the research objective of deriving the success and failure factors that could guide future implementation. Most of the case studies in implementation research used a single-case design and were descriptive in format, indicating the exploratory nature of the research.

Field study, especially mail survey, was found to be another popular research method in studying IT adopted at the organizational level. A number of field studies involved the development of models or frameworks by synthesizing and integrating information collected through survey instruments. Their goal was to validate hypothesis postulated or testing theories in IT, especially those related to success factors and IT management.

It was found that researchers were moving from a predominantly case study research method to a field study research method. Apparently, at the time of Lai and Mahapatra's (1997) study, researchers seemed to have a better understanding of IT implementation and more research effort was being spent in theory building from practice, thus signifying a growing maturity of research in the field.

STATUS OF THE RESEARCH IN INFORMATION TECHNOLOGY IMPLEMENTATION FROM 1990-2001:

For the purpose of this paper 19 articles were reviewed. The objective was to find articles that were considerably recent, from a credible source, with an emphasis in empirical research methods, and with a focus in Advanced Manufacturing Technologies and CAD/CAM.

<u>Research Focus</u>: As it was the case for the analysis from Lai and Mahapatra (1997), implementation success (52.6%) and management (47.3%) were the two most explored research topics. Additionally, researchers were interested in the planning aspect of implementation (33.3%).

It is important to note that only four studies in the specific area of CAD/CAM were found (21%). Studies focused in the area of AMT represented more than half of the total studies found (57.8%).

Technology implementation level: In all of the studies, there was an emphasis on analyzing organizational-related items associated with implementation. This was valid for the organization at large, work groups or individuals. Additionally, 13 of the studies compared the outcomes of implementation among a group of more than 2 organizations (68.4%)

Research Methodology: Field study and case study were the two most popular research methods for technology implementation research. A total of 12 out of the 19 (63.1%) studies used field study as the research method. Four (21.1%) articles reported the use of case study as the research method. In general, empirical approaches were preferred to non-empirical approaches in implementation research.

As predicted by Lai and Mahapatra (1997), it was found that researchers were moving from a predominantly case study research method to a field study research method. However, in the case of CAD/CAM research, all of the articles found used the case study research method, which may be an indication of the lack of better understanding of CAD/CAM implementation.

Additionally, the number of organizations included in articles that used field study as a research method was not predominantly large. Only six of the 12 articles used a sample size of more than 20 companies in their study. Therefore, it seems that there is a need for field studies to be done in the case of CAD/CAM, with a sample size that could provide for robust findings.

Human issues in Technology Implementation

Cleland, Bidanda and Chung (1995a) performed a detailed examination of the vast body of knowledge on Human Issues in Technology Implementation (HITI). They identified relevant issues in the following five areas:

- Philosophical approach;

- Planning and implementation;
- Employees issues;
- Organizational issues; and
- Implementation issues measurement.

<u>Philosophical approaches to technology planning and implementation:</u>

An organization's philosophical approach to technology implementation consists of the set of general underlying values with respect to human and computer roles in manufacturing process. On divergent ends of the philosophical spectrum are the technocentric and the human-centered approaches (Cleland, Bidanda and Chung ,1995a).

The technocentric approach is most commonly associated with technology implementation in the USA. This approach is associated with the deskilling or reduction of skills among the work force. Also, this approach subordinates human issues to technical issues, and is defined as containing the following principles:

- Humans are unpredictable, troublesome, and unreliable components of the manufacturing process.
- Manufacturing systems should be designed to minimize the need for human intervention.
- Manufacturing systems should be controlled by computer in order to provide flexible and rapid response to market demand.

The human-centered philosophical approach is also known as the socio-technical, human-integrated manufacturing (HIM), or people-integrated manufacturing (PIM) approach. Here, the manufacturing system focuses around the computer-aided craftsperson, and embraces the following principles:

- Workers are accepted as having skills and the development of those skills is encouraged.
- Workers are supported by and have the freedom to control technology.
- Workers are multi-skilled and divisions of skills are discouraged.
- Communication and interaction among workers is encouraged.

Until the predominantly technocratic approach to AMT implementation is supplemented by an equal concern with structure, planning, conflict resolution, team functioning, and champion skills development, we may expect to continue to see what Beatty's (1992) study has shown: only half of the ten companies embarking on an AMT voyage reached their destination. The other half were impeded by dead ends and potholes

Many authors have emphasized that new technology implementation in organizations are predominantly "technology-led". However, few analysts have attempted to account for this approach or, indeed, to spell out its consequences. In their study, Symon and Clegg (1991), describe the implementation of a CAD/CAM system in a light engineering company over a 18-month period, focusing specifically on the reasons for the adoption of a technology-led implementation style. They argue that this technology-led implementation is a form of 'satisfacing', and that this approach was adopted as a result of the differentiated and political environment, the scarcity of organizational resources, the existing managerial style and the complexity of the problem. They found that while CAD/CAM was "successfully" implemented, many employees felt they had not been consulted and that the implementation process itself was inadequate.

In addition to the differences between the technocentric, and the human-centered philosophical approaches to technology implementation, is the fact that the literature on the diffusion and implementation of innovations has tended to specify the process in terms of "stages". Early in their research Winch and Twigg (1993) supported the established criticisms of stage models in terms of their implied rationality and linearity. In fact, they found that these criticisms had some weight when applied to early results from 15 case studies of metalworking firms implementing CAD/CAM.

Winch and Twigg (1993) developed a model of the process of implementation as one of continuous changing in organizations, and tested it, in the 15 companies under study. Their model retains the following three stages typically found in the implementation literature, i.e. evaluation of the new technology, installation and commissioning of the new technology, and the stage of consolidation, but places them in a recursive relationship to each other.

Despite their initial support to the criticism of the stage models, Winch and Twigg (1993) decided to retain a stage model because it does help to identify the qualitatively different processes and their associated structures within implementation, and it facilitates comparative analysis between organizations.

Planning and implementation issues:

Planning and implementation issues are associated with scheduling and methods of adoption utilized by organizations. These issues include the scope of the implementation changes; the timing of the implementation; the methods of introduction; and the execution of the implementation. A frequent theme in the unsuccessful implementation of technology is that there is a lack of attention given to human issues in the planning stages. An equal consideration in planning must be given to human issues as well as technical issues if the expected benefits of a newly incorporated technology are to be attained (Cleland, Bidanda and Chung ,1995a).

The timing of technical, organizational, and worker issues is critical to the success of the technology planning and implementation. The involvement of users early in the implementation process ensures that the technology will meet the users' needs as well as assist in reducing resistance (Beatty, 1992; Nandkeolyar, 1996).

Pilot projects appear to be the most successful method of introducing major technological changes (Chung, Cleland and Bidanda, 1995); Beatty and Gordon, 1990). Additionally, it is better to go slowly (Beatty and Gordon, 1990). Most of the CAD/CAM implementations observed by Beatty and Gordon (1990) in their study of 10 manufacturing companies over a three-year period proceeded rather slowly. Perhaps a CAD system is installed first and then when it is working, a CAM component, such as process planning or tool path generation is added.

Simulations, in combination with pilot projects, are especially useful. While vendors most often play a principal role in technology introduction, alternative methods include the training of supervisor or peers by the vendor, and the introduction of the technology by the supervisor or peers.

A frequent them of technology planning and implementation is that system design and selection are the exclusive domain of upper management or staff specialists. This ignores the benefit of worker knowledge and removes the employee's sense of involvement, ownership, and pride of their work. Active employee involvement in each stage of planning and implementation will generate a sense of control and reduce resistance (Cleland, Bidanda and Chung ,1995a).

It is also widely recommended that a cross-functional team or implementation committee composed of middle managers and/or experts be established to carry out, modify and monitor the implementation plan (Beatty and Gordon, 1990; Cleland, Bidanda and Chung; 1995a; Harper and Utley, 2001; Sohal, 1997). Out of the 10 companies that Beatty and Gordon (1990) studied, only four used an interdisciplinary implementation team systematically, but all four achieved the results they sought with AMT.

The use of teams is even more problematic and complex than developing an effective champion or integrating systems, but Beatty (1992) argue that teams are just as necessary to ensure widespread acceptance and skills use of AMT. To gain maximum benefit from team structures, companies sorely need an infusion of team-building expertise and more emphasis on organizational development (Beatty, 1992).

The identification of a technology champion- a senior person who truly believes in, and is willing to go on a limb to support the project- is a critical factor in determining the success of the technology within the organization (Cleland, Bidanda and Chung, 1995a; Tantoush, 2001). These technology champions support the planning and implementation through their vision for utilizing AMT; their knowledge of computers and the application process; and their general project management skills.

According to Beatty and Gordon (1990) without such an individual, and an effective one at that, none of the CAD/CAM projects they investigated would have got to first base. In the six companies with such individuals, CAD/CAM was successfully implemented. In the four without them, it stagnated. Effectiveness of the champion depends on his/her abilities in fulfilling three critical roles during the AMT project- path-finding, problem-solving and implementing. They also found that one of the most common reasons for champion failure was a lack of implementation skills. Most of the champions in their study had technical backgrounds, and many had never been in line management positions (Beatty, 1992).

Beatty and Gordon (1990) also stated the important role played by what they called a corporate “godfather”. This is a person who watches over, protects the project from interference and convinces others on the executive of the value of AMT. A godfather is important to get the project going, but not necessarily to sustain it. Companies that want more innovation should ensure a supply of godfathers through various mechanisms, such as rewards for risk taking, encouragement of technical literacy at the senior level, time for planning and thinking, creativity and promoting some technically literate people to the executive level.

However, all of the findings mentioned above, do not consider a critical element in the planning phase of the technology adoption and implementation: How well is the organization positioned to derive competitive advantage from technology? .

As stated by Adler and Shenhar (1990), whether a company is contemplating a strategic change or just evaluating the implementation of existing strategy, it must thoroughly assess the strengths and weaknesses of its technological base. Moreover, they added, unfortunately, the assessment of this technological base is too often limited to a review of the patent position, the investment in leading-edge technologies, or some other equally narrow area. Managers need a framework for assessing the much broader question of how well their organizations are positioned to derive competitive advantage from technology.

Adler and Shenhar (1990) developed case studies for two organizations in the defense industry to illustrate how two companies’ strategies for moving into a new business were shaped by the strengths and weaknesses of their respective technological bases. In their study of these two companies, they developed a series of questions based upon what they defined are the four elements that managers need to take into account when assessing their own technological base. These four elements are:

- *Technological assets:* the set of reproducible capabilities in product, process, and support areas.

- *Organizational assets:* the skill profile of employees and managers, the procedures for getting things done, the organizational structure, the strategies that guide action, and the culture that shapes shared assumptions and values.
- *External assets:* the relations that the firm establishes with current and potential allies, rival, suppliers, customers, political actors, and local communities.
- *Projects:* the means by which technological, organizational, and external assets are both deployed and transformed.

It might be of interest for this study, to assess the organizational assets of the companies that will make part of the sample data. For those organizations that have already adopted CAD/CAM, it would be relevant to study whether the outcomes of using this technology are related to these organizational assets. In the case of the companies that have not introduced CAD/CAM, the assessment of their organizational assets might act as a predictor of the success in the future adoption of this technology.

<u>Employee issues:</u>

Employee issues that might impact on the success of technology planning and implementation include selection characteristics, resistance, training, and reward systems. The adoption of advanced technology changes the standards required of the workforce. Employees must now be more capable in terms of knowledge, skills, and attitudes (Cleland, Bidanda and Chung, 1995a).

Among other organizational requirements needed to harness the programmable and integration capabilities of computer-aided technologies is a workforce that is capable of, and involved in, making decisions at the point of production (Gyan-Baffour, 1994). Organizations successfully implementing IT systems seem to understand that it is important not only that employees have the proper tools to perform their job, but also that they be given the autonomy to decide how and to what extend to utilize those tools (Harper and Utley, 2001).

Increased communication among the workforce is especially important. Organizational attitude toward a new technology is critical. All personnel must specifically exhibit increased adaptability, flexibility, and the sense of discipline to follow well-established procedures (Cleland, Bidanda and Chung, 1995a; McDermott and Stock, 1999).

Employee resistance at all organizational levels to change is one of the most troublesome factors in technology implementation. Fear for the unknown, failure, job loss, and power loss are the reasons behind the resistance.

Effective efforts toward overcoming resistance include worker involvement, communication, and training (Beatty and Gordon, 1990). Involvement includes worker participation in the planning, selection, and implementation process (Beatty, 1992; Cleland, Bidanda and Chung, 1995b; Nandkeolyar, 1996). Other organizations have attempted to reduce resistance through the constant communication of planning and implementation impact on the workforce (Beatty, 1992).

In his study of over 200 firms, which were potential users of AMT with computer-aided automation, Gyan-Baffour (1994) found that the capacity to participate, the technical skill formation, and the production information sharing factors of employee participation all positively and significantly affected most performance measures. Employee participation has a positive and significant impact on productivity, production flexibility, and quality (Gyan-Baffour, 1994).

Companies that want successful AMT projects must help to maintain a balance between senior and lateral support. This balance is facilitated by educating all levels about AMT before embarking on the project (Beatty, 1992).

The adoption of technology frequently requires extensive investment in both the training of new employees and the retraining of existing employees. Significant organizational choices involve the source and methods of training (Cleland, Bidanda and Chung, 1995a). Companies which do not carry out adequate training of their staff (both technical and managerial) will only achieve partial benefits from their AMT implementation (Sohal, 1997).

However, it was surprising for Sohal in his longitudinal study of Australian manufacturing companies (45 companies in 1989 and 107 companies in 1993), to find that companies surveyed in 1993 reported less need for, and implementation of, training in AMT. Sohal (1997) considers that the drop in training activity might be explained by the tough economic climate over the four years prior to the study.

A better situation exists, if the employees play a participative role early in the implementation. For example, select employees can receive training prior to the arrival of the new equipment and can assist in the training of other employees after it arrives. Finally, since technology is continuously changing, training must be considered a continuous process (Cleland, Bidanda and Chung, 1995a).

The need of organizations to utilize advanced technology, which will help them use different systems to reward worker performance, is a key human issue. Two reward systems that appear to support new technology are skill-based pay and gainsharing programs. Beatty (1992) found that many companies do not encourage champions to take risks, and some champions lie low or leave the company. She also found that another reason for champion failure is the lack of sufficient reward or support.

Organizational issues:

Change may be required in organizational structure, production team composition, and management style. New technologies provide organizations with the potential for increased flexibility and responsiveness. In order to fully realize this improved flexibility and responsiveness, changes in organizational design must occur at both high and low levels. At the functional level, barriers between departments must be removed. At shop floor level, manufacturing must be reorganized into autonomous units that can function independently based on local demands (Cleland, Bidanda and Chung, 1995a).

Successful companies might also realize that in order to gain maximum benefit from IT tools, it is important that the tools be modified or manipulated for the best possible results. The organization must contain enough flexibility to accommodate a shift in planning or technical retooling that provide success (Harper and Utley, 2001; McDermott and Stock, 2000).

Companies considering AMT investment need to develop an overall strategy that addresses compatibility issues, both present and future, and they need to plan at a high enough level to overcome parochial department orientation. To do so, they must either develop a degree of technological sophistication at the strategic level or obtain expert advice from inside and outside the organization. To a certain extent, cooperating with vendors and ensuring that they have some stake in the outcome will help, but their advice is not always disinterested (Beatty 1992).

These new technologies impact both between and within an organization's functional departments. On the functional level, AMT permits improved interdepartmental information sharing. However, this improved capability maybe restricted by the existence of functional barriers. The use of multi-functional teams for activities such as simultaneous engineering enables organizations to exploit the enhanced flexibility and responsiveness capabilities of AMT.

The extensive information capability of AMT systems allows critical production information to be accessed at the shop floor level. This improved access permits decision making to be lowered to the operator level. With decision making and multi-skills capability, the workforce can not operate as semi-autonomous teams (Cleland, Bidanda and Chung, 1995a).

Flexible automation by itself will not increase productivity; the critical ingredient is the work organization (Krafcik, 1989). Furthermore, it is estimated that the relative contribution of workplace innovations to gains from advanced technology is between 40 and 70 percent (Bessant and Lamming, 1987). Firms with higher levels of decentralized decision-making structures will likely gain more from the programmable and integration properties of computer-aided technologies and thus utilize more of these advanced technologies (Gyan-Baffour, 1994).

Using data from a sample of 97 manufacturing plants, McDermott and Stock (1999) examined how organizational culture is related to outcomes associated with AMT implementation. They found that none of the culture types (group culture, hierarchical culture, developmental culture, and rational culture) was associated with either of the tangible outcomes (operational and organizational benefits). A somewhat balanced cultural orientation encompassing more than one orientation (in this case both control and flexibility) would likely lead to positive competitive outcomes (McDermott and Stock, 2001).

An organization characterized by group culture found value in the process of AMT implementation, perhaps as a capability -or team building exercise, even in the absence of operational and organizational benefits. It is possible, that an organization characterized by developmental culture would find a low level of satisfaction with an AMT implementation that, from their perspective, did not work (McDermott and Stock, 1999).

Getting a robotic or CAD system “up and running” in the short term may well be influenced more by technical skill and managerial actions than by organizational culture. However, implementation outcomes that may take longer to appear, such as overall satisfaction or competitive performance, do depend on the organization’s culture (McDermott and Stock, 2000).

It is important to focus not only on existing cultural attributes that promote successful implementation, but also to identify cultural attributes that would slow or halt success. The 3-year study of 18 companies involved in government and commercial ventures performed by Harper and Utley (2001) suggests a correlation between specific cultural attributes and the successful implementation of IT systems. They found that people-oriented rather than production-oriented aspects exerted the most significant influence.

In their study, Harper and Utley (2001) also found the following cultural attributes to have a positive correlation with the successful implementation of IT (in descending order): autonomy, trust, team-oriented work, flexibility, and sharing information freely. They also showed the following cultural attributes to hold a negative correlation with the successful implementation of IT (in descending order): rule orientation, compliance, carefulness, preciseness, and predictability.

How to measure the success of new technology:

A number of attempts have been made to assess the success of a technological implementation. Assessment methods range from the examination of production records to the administration of surveys. Some methods base success on production records including downtime, utilization rates, and parts per system. Another method is to focus on flexibility, downtime labor reduction, cycle time, quality, and reduced work in progress from a technology buyer’s viewpoint. Many others have concentrated strictly on the financial aspects of implementation.

While these strictly objective measures may provide information on the end technical result of the implementation, a comprehensive examination must also include success from a human viewpoint. For this reason, behavioral aspects indicating success and satisfaction must also be included. Well-established indicators in this area include turnover, absenteeism, tardiness, and grievances (Cleland, Bidanda and Chung,1995a).

In 1994 Gyan-Baffour assessed the impact of higher levels of AMT and employee participation on productivity, quality, and production flexibility. The inclusion of employee participation variables as predictors of performance led to about a 50% reduction in the influence of advanced manufacturing technology on performance. The lack of robustness in the advanced technology coefficients suggested a linear association between advanced technology and employee participation.

The reduction in the effect of AMT on performance in the full model, and its linear relationship with employee participation indicates that advanced technology’s influence on performance has 2 components: a direct effect and an indirect effect via its linear association with employee participation (Gyan-Baffour, 1994).

According to Beatty and Gordon (1990), the AMT project should not begin before some realistic, long-term and short-term objectives have been set, preferably by top management in collaboration with those responsible for its implementation. In the companies they studied, only a senior level interdisciplinary team was able to ensure compatibility and integration of AMT.

In their study they found that in many cases, objectives were fuzzy, did not fit the competitive necessities of the firm or were not widely communicated, understood or accepted (Beatty and Gordon, 1990). Goal achievement was difficult to assess in some cases because the goals were stated vaguely.

Many companies make the mistake of setting only short-term financial goals for AMT. AMT usually will not generate quick returns because many projects take from one to two years to install fully and even more time to realize productivity increases or other benefits. Beatty (1992) found that companies investing in AMT in order to improve their market position were likely to have clearer, more specific, more challenging, and ultimately more motivating goals than those companies that focused on short-term financial ones.

Another missing aspect in measuring the success of AMT implementation is the "post-implementation" review. Sohal (1997) found that the respondent's disregard of the post-implementation audit reflected the low priority attached to establish the relative success in the AMT endeavor, and to identify areas which companies can strive to improve. He found it disappointing that post-audits of AMT investment had not been carried out by a significant number of responding companies in both 1989 and 1993 surveys. For both samples, he found that only one quarter (25% in 1989, and 27.8% in 1993) of respondents indicated that a formal post audit was carried out.

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