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Relationship between *a priori* standards and the acceptance of computer-aided systems engineering products

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Title

Relationship Between *A Priori* Standards and the Acceptance of Computer-Aided Systems Engineering Products

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University

by

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This is to certify that the dissertation prepared by Joyce M. Rowe entitled RELATIONSHIP BETWEEN A PRIORI STANDARDS AND THE ACCEPTANCE OF COMPUTER-AIDED SYSTEMS ENGINEERING PRODUCTS has been approved by her committee as satisfactory completion of the dissertation requirement for the degree of Doctor of Philosophy.

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Glossary

ACM - Association of Computer Machinery. An organization of computer professionals.

bubble chart - a type of data-flow diagram.

CAD/CAM - computer-aided design/computer-aided manufacturing. Automated design aids used by engineers.

CADME - computer-aided development and maintenance environment

CASE - computer-aided software engineering. (Also, computer-aided systems engineering.)

CBIS - computer-based information systems.

CIS - computer information systems

CLD - composite logical design. A term used by Learmonth and Burchett to describe the phase which combines the third normal form relationships with the logical data structuring technique to produce a data structure model.

DBMS - database management system. The physical constructs of the database system and the logical interfaces which support the data storage and retrieval.

DFD - data-flow diagram. A graphical representation describing the underlying nature of what occurs in the various business areas of the organization.

DSS - decision support systems. Computerized systems which provide information necessary for decision making.

ER - entity-relationship. A structured methodology used to convert user requirements into well-designed databases.

ERD - entity-relationship diagrams. The graphical system used in the entity-relationship approach to system design and modeling.

GDDSS - group-developed decision support systems. Systems developed by more than one person.

I-CASE - integrated CASE techniques. Various CASE tools which support different portions of the systems life cycle integrate with one another without having extensive manual intervention.

JAPS - joint application planning sessions. The information systems personnel and the users meet and plan the new system together in one or more joint sessions.

JADS - joint application design sessions. Sessions in which the information systems personnel and the users meet to design the portions of the new system, such as screen design, together.

LDST - logical data structuring technique. A methodology supported by Learmonth and Burchett which considers data relationships and required access paths between related data.

Lower CASE - A computer-assisted component that supports physical system development.

Middle CASE - A computer-assisted component that supports systems analysis and design.

MIS - management information system. A computerized system which supplies information to management for decision making.

SDLC - systems development life cycle - the stages which the system goes through from its inception through its installation.

STD - state-transistion diagrams. The graphical representation used to show the information as it moves from one state to another within the system.

toolkit - CASE aids that focus on support of one phase of software development or system task, such as systems analysis, database design, etc.

TNF - Third Normal Form. A data element/key relationship used in establishing database records in order to reduce redundancy.

Upper CASE - A computer-assisted component that supports enterprise, environment and planning modeling.

workbench - A collection of integrated software tools within CASE that provide automated assistance for software systems analysis, design, etc.

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Abstract

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Because of the resource expenditures required in systems design and development efforts, techniques and tools that profess to improve the quality of such systems have attracted increased attention. One such tool is the group of software products available under the nomenclature of Computer-Aided Systems Engineering. However, companies that have installed such design and development products have experienced a resistance to the use of such tools from the designers and developers who utilize them. Due to the expense incurred when selecting, installing, and training for CASE, information systems managers have been hesitant to purchase these software aids unless they were assured that employees would utilize them. This research effort examined several factors that were considered significant to the acceptance and usage of such front-end CASE systems.

The primary focus of this research effort centered on the effect standardization had on the overall acceptance to the CASE product. Because front-end CASE tools required the use of one or more methodologies in the design and development of systems, the researcher attempted to determine whether there was a significant relationship between the existence of enforced methodological standards prior to CASE installation and the resulting acceptance of the product by the systems designers.

Two additional questions were also evaluated. For those companies that had installed CASE tools an attempt was made to evaluate the importance of selecting a CASE product that provided the same methodology as the analysts had used before CASE was implemented. The researcher felt that using a product offering a like methodology would improve the acceptance to the product.

The third issue concentrated on those companies without a priori standards. The question asked concerned whether offering education on specific methodologies as well as on the techniques of the CASE product would improve the overall acceptance to the product.

All three issues concerned techniques and procedures managers in information systems departments found effective in increasing the acceptance, and ultimately the use, of CASE tools in an effort to improve systems design and development.

INTRODUCTION

Interest in providing adequate support environments for the development of management information systems has been growing for several years. Having identified information systems as a capital resource, organizations began realizing the need for more certainty in the design and reliability of those systems. Since the mid-1970s, the development approach has evolved along with the growth of methods used to aid both project management and specification. Organizations have begun turning to more formal methods of systems development, and, most recently, to automated tools, such as Computer-Aided Systems Engineering (CASE), to support these methods. The implementation of CASE tools is undertaken with the specific goals of increasing productivity and improving system quality. Yet, companies that have installed such products often find their systems developers resistant to these tools. Needless to say, the introduction of the software product, if left unused by the systems developer, will provide neither of these desired benefits. This research considered one factor that might affect the acceptance (measured by the designer's use of and affinity for the product) encountered with the implementation of CASE products; specifically, attention was given to those companies that maintained systems methodological standards prior to CASE implementation versus those organizations that imposed such methodological standards only after the product was selected and installed. The study examined the development procedures of the most-popular methodologies, the adaptation of these procedures into existing automated techniques, and the level of training provided in both the automated techniques and the underlying methodologies.

This chapter presents the research problem (including brief definitions of problem concepts) and then discusses the significance of the proposed study. It includes an examination of the general CASE concepts and defines further concepts and terminology pertinent to the study. The chapter then concludes with a discussion of the scope and limitations of the proposed research and a statement of the hypotheses to be tested.

The second chapter reviews related research and literature pertinent to the study. The third chapter discusses the research method used, followed by a chapter that discusses the data analysis and results. A final chapter presents a summary of the research and the author's conclusions.

The Research Problem

The problem studied:

> To what extent does the standardization to a specific methodology supported by a CASE product affect the overall acceptance and usage of that product?

Organizations, whether large or small, develop information systems to provide aid in supporting managerial decision making, developing new services or products and seizing competitive advantage [Chen, Nunamaker and Weber, 1989]. The ever-increasing demand for new, more complex and higher-quality applications software comes at a time when the backlog of requests and maintenance needs continue to grow [Necco, Tsai and Holgeson, 1989; Burkhard, 1989]. Because the development of such information systems requires major resource expenditures within the organization, the investment in personnel, software, and hardware made during the systems development and maintenance cycles has become a major cost factor to the enterprise. Having expended vast sums in these areas, today's management expects to see the demand for these support systems answered with only moderate increases in computer hardware and software costs and human and company resources. Therefore, any technique or procedure developed to aid in the development process, to make it more economical and of higher quality, is of interest to the information systems manager.

The typical information systems development technique has evolved into a series of steps or phases, each unique yet related to the others. Known as the Systems Development Life Cycle (SDLC), these phases are:

Business and Information Systems Planning

Requirements Analysis

Logical Design

Physical Design

Development and Implementation

Operation and Maintenance

The basic concept of Computer-Aided Systems Engineering is software that assists in the development of software. Although there are some CASE tools that are advertised to support all phases of this life cycle, most products are currently being used for activities ranging from the requirements analysis phase to the programming and testing phase.

There are several ways to describe CASE tools. Those tools that align the software strategy with the business goals by analyzing the application are called "upper CASE" or "front-end CASE"; they emphasize such upstream activities as planning, analysis, design, and prototyping of systems. The "lower CASE" or "back-end" tools utilize given specifications and produce applications code. These are efforts that support the downstream activities of programming and maintenance [Mason, 1988].

According to James Martin, "To stay competitive in the future, corporations will depend on being able to create effective computer applications quickly" [1988]. CASE software is composed of various modules, each designed to aid in one or more of the systems life cycle phases, in order to provide speed and accuracy in systems development.

The term I-CASE, or integrated CASE, was first used to describe the full spectrum of tools covering all aspects of the system life cycle, including computer-aided planning and modeling, computer-aided design linked to code generation, documentation generation, and project management aids. An important distinction between I-CASE and CASE tools is that I-CASE stores design information, created via intersections with front-end workbenches, into a central design repository. This repository then generates executable code. The individual phases of planning, analysis, design, and coding are tightly coupled. Such an integrated system enables modifications to be easier, is less prone to error and enforces a rigor and standardization throughout each step of the life cycle.

Much of the recent attention given to Computer-Aided Systems Engineering has been focused on tools that automate systems analysis and design, as this was an area deemed most crucial to applications development. Many systems designers believed that most of the defects that were prevalent in newly installed systems were built into the system from its conception--the logical design--and were then exponentially multiplied and reinforced throughout the entire development process. Laborious efforts were required to uncover and correct these errors during the later stages of development. Front-end CASE tools have targeted the business systems planning and the systems analysis and design phases in an attempt to ensure that systems requirements were well sorted out and well documented from the initial stages. In Database--The Second Wave, James Martin stated, "At the top is strategic planning, which encompasses the business strategic planning functions that are the foundation for subsequent phases of the development process. The next level is analysis, wherein a model is built of the fundamental data and the processes needed to run the particular enterprise" [Holland, 1985]. Thus, system design structure was well defined before it was passed to the encoding phase.

Because of the importance placed on this front-end phase of development, numerous vendors have collectively developed at least 100 products for this design step; yet, this market, by all reports, is still in its infancy. A recent study conducted by Montgomery Securities showed that the upper-CASE segment of the market is projecting a total growth of 35-40 per cent from its 1987 base of $50 million while the lower-CASE market will expand approximately 30 per cent from a base of $32 million [Janus, 1988].

To reap benefits promised by sophisticated automation tools, the tools must be supported by a consistent software development methodology [Sullivan, 1988; Burkhard, 1989]. In fact CASE tools require that a systems development environment be based on structured techniques and well-conceived systems engineering methodologies. Computer-Aided Systems Engineering, by its name, implies discipline; yet many Management Information Systems (MIS) departments have not strictly enforced such discipline [Martin, 1988; Snyders, 1987]. Thus, the introduction of the CASE product signals the inception of stringent and well-enforced standards targeted to one methodology. "The key to the success of any CASE tool within an organization, experts emphasize, is a standardized development environment that uses one methodology throughout" [Janus, 1988].

Though many have agreed on the need for standardization within the organization, to date CASE designers and vendors have seldom been concerned with the human and social factors involved in information systems development. CASE, in fact, has been touted as a means to rationalizing and automating labor- and knowledge-intensive manual processes, thereby driving and monitoring developer productivity [Chen, Nunamaker, and Weber, 1989]. Yet, such benefits cannot be accrued unless the systems developer effectively uses the tools. Zuboff suggested that the benefits of information technology are experienced only when it is used to "informate" or free people from cognitive overload so that they concentrate on developing a more comprehensive, explicit, and abstract knowledge of their work [Zuboff, 1988].

Systems developers, just like other users, must realize a personal advantage from using the software tool before the organization will realize a productivity gain. Therefore, some thought must be given to ways of making the CASE tool "acceptable" (one that is often used) by the systems analyst. One area of concern is whether the CASE tool supports the same systems methodology in which the designer or analyst was schooled or experienced.

Another area of concern is whether standards are enforced and followed within the development period. Does the installation of CASE software impose methodology standards where there were no previous standards? If so, is the designer and analyst resistant to the standards, the product, both or neither?

Significance of the Study

Several key characteristics of this study may have a direct impact on either the decision to implement the CASE tools or the approach used during the implementation of the product. Understanding whether the existence of a priori methodological standards affects the willingness to accept and use the CASE product by the systems developer may enable the manager to better prepare his or her department for the product. The manager can better understand how completely the CASE product conforms to the methodologies the analysts and designers were previously using in order to accept the product. This knowledge is expected to aid in the selection and training process when implementing the CASE tool.

To the theorist, this present study provided the insight as to the possible effect one specific factor--methodological standards--had on whether the analyst accepted the CASE product. In the future, other factors influencing acceptance and use may then be studied.

Types of Systems Development Methodologies

Systems designers differed in the images and constructs they used in thinking about data and its interrelationships. This plethora of constructs became evident through the multitude of modeling techniques and structures used at different stages within a phase of the life cycle to graphically express conceptual structure. While some designers had received formal education in some of these methodologies, others had developed special techniques and procedures through their experience in the systems environment. The types of graphical designs available at the various stages of the life cycle, though different in technique, generally fell into the following groups [Danziger and Haynes, 1989]:

1. Planning - this phase defined the business functions, developed the enterprise data models, diagrammed the entity relationships, and defined the technology requirements;
2. Analyzing and Designing - this phase specified the functional design criteria, constructed data flow diagrams and structure charts, developed logical data models, diagrammed canonical charts, and defined hardware and software requirements;
3. Coding and Testing - this phase developed flowcharts, diagrammed Yourdon charts, created Hierarchical Input-Processing-Output (HIPO) charts, coded and tested programs, and created physical databases;
4. Implementing - this phase developed the Pert Charts and installed the system into the production environment; and
5. Maintaining - this phase consisted of the ongoing activities of correcting and improving installed systems.

When a major portion of the analysis was concerned with the design of the database, the systems life cycle methodology was viewed as a series of steps [Learmonth and Burchett, 1983]. These were:

1. Third Normal Form Data Analysis - reviewing the existing file layouts, input documents, planned output reports and screen layouts. The data elements were optimized into storage relations and then evaluated as to the appropriate third normal form (TNF). Keys for groups of data elements were then established.
2. Logical Data Entity Modeling - considering all of the systems requirements. Termed the Logical Data Structuring Technique (LDST), this stage produced an entity model that considerd the specific data relationships and the required access paths between related data.
3. Composite Logical Design (CLD) - clustering the data elements. In this stage the results of the TNF (#1) and the LDST (#2) were combined. First, an LDST model was created from the TNF elements (data structure model); then validation rules were applied to ensure the functional descriptions were met; lastly, a final CLD data structure model was created and passed to the next phase.
4. First Cut Physical Design - applying rules of consistency and need against rules for the physical requirements of the database system.
5. Physical Design Control - insuring that design objectives have been met through database calls.

The systems analysis and design phase within the systems life cycle has been described as hinging on the requirements and design of the database [Holland, 1985]. Three main areas stressed in his views of database construction and operation concerned:

1. Systems Design - defining the business activities and the system objectives. (Entity-relationship diagrams were used at this level.)
2. Logical Database Design - determining the entities in strategy planning and designing integrated canonical third normal form databases. Ultimately, the user views were established. (Canonical diagrams and data flow diagrams were used at this level.)
3. Physical Database Design - implementing the logical TNF databases into DBMS. (Physical tree diagrams were used at this level.)

Several modeling approaches reviewed appeared to attack the systems problem by utilizing a process-oriented methodology that concentrated on defining the functional flows of the system or the basic context included in the system. The assembly-line diagram, a type of modified version of the Warnier/Orr diagram, was an example of this approach. Other approaches, perhaps more widely accepted, followed a data-structured model.

Regardless of the type of philosophy the organization followed, standard methodologies using graphical charts were applied at various stages of the life cycle. These were the types of analysis and design diagrams that were prominent in CASE systems. Some of the most widely used modeling techniques being supported with automated diagramming aids were:

1. The Entity-Relationship Approach. This approach provided a structured methodology that systematically converted user requirements into well-designed databases. Used primarily in the requirements phase of the systems life cycle, it was applied during the systems design phase. Six years ago a survey of Fortune 500 companies published in ACM SIGMOD proceedings, 1983, reported that the entity-relationship (ER) approach ranked as the most popular in data modeling and database design. Using specific symbols to represent entities and their relationships to one another, the entity-relationship diagram (ERD) identified ER types and associated attributes.
2. The Gane-Sarson Approach. This method of systems design and development emphasized

the creation of a logical model; it was used in the analysis phase of the cycle. The purpose of logical modeling [Gane, 1977] was to take a quick and accurate assessment of the necessarily vague ideas about systems requirements and convert them into precise definitions. To accomplish this, the systems analyst and designer initially developed a system-wide data-flow diagram (DFD) describing the underlying nature of what occurred in the various business areas affected by this system.

3. The Yourdon Approach. Used by analysts for over 20 years, this collection of techniques was often referred to as structured techniques and included such items as structured programming, structured design, and structured analysis; thus, it covered several stages of the life cycle. For the systems analyst and designer, there was a variety of graphical diagrams used to model the requirements and the architecture of an information system. The Yourdon method included the original data flow diagram, extended to support real-time systems, entity-relationship diagrams (ERD) and state-transition diagrams (STD).

4. The DeMarco Approach. A type of structured analysis designed to use the basic concepts of the Yourdon approach but varying the types of symbols and linkages in several of the diagram types. It, too, covered several stages included in the systems development life cycle.
5. The Structured-Design Approach. A methodology developed to use a data flow diagram (often called a bubble chart) to show the transformation of the structure of a processing problem. It then produced a model of the software structure used to solve that problem.

"With CASE tools, real structured design on problems of interesting size becomes truly practicable for the first time" [Orr, 1989]. The diagram editors of CASE systems were designed to assist in developing and refining complex graphical models. Yet, these tools were not a replacement of or substitute for systematic methods. Success rested on the method, not the tool.

The Standards Issue

To be most effective, CASE tools required a systems development environment based on structured techniques and well-conceived software-engineering methodologies [Sullivan, 1988]. Many companies interested in adopting CASE tools, however, lacked such a disciplined environment [Sullivan, 1988]. Generally, the installation of a CASE system imposed some sort of standards on the development process; training in the usage of CASE often accompanied the selection and installation of the software.

A significant finding in one study concerned the amount of time most developers required to become adept in the use of CASE [Loh and Nelson, 1989]. In this study at the University of Houston, 40 programmers, analysts, and systems designers at 12 companies were questioned on their use of CASE. They reported that they spent an average of 69 hours learning to use CASE tools on their own and 86 hours in company-operated group-training sessions and private instruction. No attention was given in this study to the training provided in the underpinnings of the methodology that the CASE tool supported.

This same study [Loh and Nelson, 1989] also emphasized that a lack of involvement in selecting the tool directly affected the amount of training required on that tool. Again, no attention was given to whether this lack of involvement and/or training had a direct effect on how often the CASE product was used.

Scope and Limitations

The scope of this study included a sample of those organizations having large mainframe computer systems in place and a functioning information systems department. The organizations selected were assumed to include a resident department actively involved in designing and developing new systems on an ongoing basis. The design and development effort of one or more projects must have extended over a two-month time period, thereby ensuring that the projects utilized significant information systems resources and personnel within the department.

This study tried to target large companies with data processing and information systems departments employing a minimum of 40 people. Departments with fewer than 40 employees were thought too small to have implemented CASE products. Therefore, any findings from this study are not to be considered applicable to small organizations.

Several issues that this study did not consider included the effect CASE products had on the productivity of the information systems department and the most widely used or most effective methodologies being employed. Nor was there an attempt to determine the most effective CASE product in use. For this research effort CASE products and methodologies were used in a generic sense rather than a specific sense.

To determine the acceptance of a particular product, an effort was made to determine the usage of that product. This research assumed a positive relationship between the acceptance and the usage of a CASE product.

Research Questions

1. Is there a significant difference in the usage of CASE systems between those companies that enforced systems standards before the tool was implemented and those companies that did not?
2. In those companies with enforced standards prior to CASE, is there a significant difference in the usage of CASE systems between those companies that imposed a methodology standard different from the one imposed after CASE implementation versus those companies that imposed the same methodology both before and after CASE installation?
3. In those companies with no enforced standards prior to CASE, is there a significant difference in the usage of CASE systems between those companies that provided training in the selected methodology and those companies which provided no methodology training?

Summary

This chapter provided descriptions of the systems life cycle approach to systems development and discussed reasons for increased interest in Computer-Aided Systems Engineering products. A review was made of the primary types of methodologies used in the front-end development phases. Because of the resources expended during systems design and development Computer-Aided Systems Engineering (CASE) tools have received increased attention among information systems managers. Yet, even when users have experienced quality and productivity gains with the use of CASE products, they have remained resistant to using these tools. This research considered some possible reasons for this resistance to CASE use. The next chapter continues this discussion with a review of the literature concerning systems development and the use of CASE systems.

REVIEW OF THE LITERATURE

Barry Boehm, in a report published in 1973, projected that software costs would, by 1985, reach or exceed 90 per cent of the total cost of data processing [Chilkofsky and Rubenstein, 1988]. Though hardware costs have been declining, personnel costs in the labor-intensive software development arena have been constantly rising. Such increased costs have forced business managers to consider adopting tools and aids that make software development more economical. The computer-aided software engineering (CASE) tools have been touted as such an advance.

The traditional approach to systems development has been characterized by informal guidelines, lack of standardization, and minimal documentation [Gane and Sarson, 1979]. Historically, analysts have collected an assortment of user-provided documents and lists of wants and needs; evaluated the requests within the limits of the analyst's experience, the programmer's abilities, and the computer's processing capabilities; and eventually produced a "system." The entire process was often viewed as an art rather than a science [Chilkofsky and Rubenstein, 1988].

During the early 1970's some basic discipline, based on models of the systems development life cycle (SDLC), was introduced to design strategy in the form of project-management methods. These methods attempted to control the development process by producing lists of checkpoints through which the evolving system progressed. Extensive effort was given to the area of documentation, though this documentation, produced in the development phase, was seldom updated or maintained once the project passed that particular checkpoint. When CASE technology was first introduced in 1984, it was touted as a means of revolutionizing the systems development process. Since 1985, at least 100 vendors have entered the CASE market [Charles Martin, 1988]. The CASE products were expected to shorten development time, increase effectiveness and change the approach to systems development from an informal process to a disciplined process.

First-generation CASE products were designed to assist systems analysts and designers in increasing productivity, improving quality, and achieving greater management control in the development process. They consisted of a combination of personal computer-based hardware and software that captured analysis and design information and allowed users an automated means to create diagrams, describe systems and prepare documentation. First-generation CASE systems were composed of one or more of the following components: the data dictionary, graphics, reports definition, dictionary reporter, quality assurance, screen definition and specification definition [Shields, 1988]. Several primary benefits offered by first-generation CASE systems were that they:

1. provided automated diagramming and documentation aids;
2. emphasized necessity for spending time in the analysis and design phases before beginning the programming phase;
3. required strict adherence to structured techniques and top-down design;
4. improved communications among developers and between developers and users; and
5. provided a means of validating the design at an early stage of development.

However, there were many areas in which these first systems showed major weaknesses. Among those weaknesses were:

1. limited capacity of diagrams;
2. limited capacity of data dictionary, if available;
3. lack of support for multiple users;
4. limited and cumbersome integration of data dictionaries; and
5. lack of integration with other tools already being used in the MIS department.

Advanced features, a more expansive architecture, and a more comprehensive approach to the systems development life cycle were improvements incorporated in second-generation CASE systems. These systems used the processing power of the mainframe, the distributed graphics capabilities of the microcomputers, and the sharing features of local-area networks. Several packages were advertised as being totally integrated through "seamless" software interfaces, providing data sharing from one phase of development into another through the entire development cycle.

Components available on second-generation systems included:

1. a central dictionary on the mainframe;
2. code generators;
3. project dictionary and reporters;
4. local dictionaries on the project;
5. extended graphics;
6. quality assurance;
7. strategic planners;
8. specification definition;
9. report definition; and
10. screen definition (painters).

Several of the drawbacks to the second-generation systems were:

1. upfront costs of the software and hardware (currently the cost for 50 developers can

exceed $1 million, excluding the cost of the mainframe [Shields, 1988];

2. non-support of majority of features by second-generation products;
3. inoperable code in portions of software sold to users;
4. slow functional processing speeds on the micro-computers; and
5. inadequate coverage of the complete systems life cycle.

Many vendors and developers expect the next generation of CASE systems to provide more automation to the systems life cycle, allowing developers to generate systems without providing as much detail as was earlier required. Artificial intelligence (AI) may be used to store knowledge about the systems environment for reference on later projects. Such a retention of knowledge will aid in handling the physical design of the database, identifying risk areas and simulating business operations during the modeling and programming phases [Shields, 1988]. One of the AI-based products already being tested is the ASPIS system which claims "to exploit artificial intelligence techniques in a software development market" [Puncello, Torrigiani, Pietri, Burton, Cardile and Conti, 1988].

According to a 1988 report from Case Research Corporation, Bellevue, Washington, CASE is still being preached about more than it is practiced although companies and products continue to enter the market. The survey was taken from commercial mainframe MIS shops with regard to current use of CASE products; the results demonstrated relatively low CASE activity and a low level of CASE preparedness. This report, in fact, discovered few companies using any formal analysis and design methodology. Approximately 70 per cent of the respondents reported less than 25 per cent of their programming staff had been trained on CASE tools. Of the primary reasons cited for not using CASE tools, the first was its newness; the second, its cost; and the third, the lack of standardization and consistency in the various modules provided by CASE vendors, creating a barrier between the staff and the products [Margolis, 1988].

Of the studies that have been made of organizations using CASE systems, many of them have concentrated on the issue of productivity. Two researchers reported on a study undertaken to ". . . investigate the various functional and behavioral aspects of CASE and determine the impact it has over manual methods of software engineering productivity" [Norman and Nunamaker, 1989]. The target group consisted of MIS professionals performing systems analysis functions using CASE technology. The subjects ranked pairs of CASE product functions (i.e., data flow diagrams, structure charts, presentation graphics, etc.) in terms of how they perceived the similarity of each one affecting their productivity. Ninety-one professionals responded to the questionnaire. The results showed that the top three items deemed most helpful in improving productivity were data flow diagrams, data dictionary support, and project standardization.

Using the responses from a 1988 Annual Index Technology Corporation User Survey, one research effort reported a 25 per cent productivity improvement for the analysis phase, a 20 per cent improvement for the requirements definition phase, and a 30 per cent improvement for the maintenance phase [Danziger and Haynes, 1989]. Yet, in a February 16, 1989, issue of Computerworld, researchers found fewer than 10 per cent of mainframe users in North America with CASE systems implemented, and of those, 80 per cent used the systems only on occasion.

One reason given in this report for lack of use was the difficulty in changing the organization's techniques in systems development. Danziger and Haynes felt that IS management must restructure their approaches to such management functions as organizing, staffing, directing, and controlling, in order to achieve success in implementing CASE systems. They mentioned two areas of interest as particularly important: the training programs should have a dual focus, addressing the cultural effects of the use of CASE as well as the actual techniques, methods and tool functionality; and the technology should provide a great deal of structure and capability. Though these observations have not been formally tested, the researchers believed them to be important because of the feelings and comments expressed by the respondents.

A more recent report concerned with productivity advances was performed by Computerworld and reported in the October 23, 1989, issue [Cortese, 1989]. In this study the respondents were given a list of several tools and techniques that they viewed as having the greatest impact on productivity. The tools and techniques listed included CASE, relational database, prototyping, development methodology, fourth-generation languages, application generators and reverse or re-engineering. The results indicated that CASE systems had the greatest effect on productivity in information systems departments.

Another issue of Computerworld reported that one of the major implications of CASE products used within the MIS department was the shift in attention and time expended in various phases of the systems development life cycle [Shields, 1988]. The traditional approach without CASE tools suggested that systems analysts spent less time and fewer resources in analyzing and designing a new system than the programmers spent in coding and testing. With CASE, time and resources committed to development shifted, so that more time and resources were dedicated to the early stages of analysis and design and less to programming and testing.

Researchers have also tried to determine some of the factors given by organizations for the postponement or cancellation of the selection and implementation of CASE products. One such effort reported that, although advocates of CASE claimed various benefits, such as higher productivity, higher quality, and easier maintenance, they also indicated that fewer than 4 per cent of potential users were actually using the products [Burkhard, 1989]. Among the implementation concerns he listed were obstacles such as methodology, standards, and training. He felt that, for CASE tools to be successful, the organization must enforce a structured methodology; yet, there remained many organizations that do not impose such structured techniques on their analysts and designers during systems development. He also felt that training was a critical issue when implementing CASE systems. Learning the mechanics of the product was simple, according to Burkhard; to gain maximum benefit, the organization had to make significant investments in educating their personnel in structured methodology as well as in specific product usage.

A report concerning the IBM CASE/MVS Project [Symonds, 1988] listed three primary objectives of the CASE-supported development process:

1. a design discipline that ensured stable specifications . . . at a sufficiently early point in the life cycle;

2. an implementation discipline that used formal inspection to ensure that programs met their specifications and had no design or implementation defects; and
3. a build-and-test discipline that tracked program libraries . . ., controlled the production of test environments, and controlled systems testing, problem location, and problem repair.

These disciplines relied heavily on automated techniques designed to increase administrative control over various design and development processes. Yet, according to the report, ". . . administrative controls have not noticeably improved the working environment for individual programmers and designers, which is what must happen before the next major productivity breakthroughs can occur" [Symonds, 1988].

Since 1985, at least 100 individual vendors have marketed CASE products [Charles Martin, 1988]. The productivity improvements reported by various users tended to concentrate around four advances:

1. methodology training and enforcement;
2. support for systems-analysis diagrams;
3. single-entry specification bookkeeping; and
4. reminders and consistency checks.

Several inherent limitations have been uncovered within CASE tools that reduce the possible productivity gains. Two of the limitations given were methodology constraints and graphic-artist requirements. The methodology constraints existed primarily because the tool did not support techniques the analysts wanted and needed for a particular set of applications. The second limitation occurred because the analyst was required to become a graphic artist, making countless decisions about the page symbols and text layouts. A data flow diagram that might be sketched by pencil and template in 20 minutes might require one to two hours with an interactive graphics tool.

The challenge, then, was to provide a tool that made the development process easier. One researcher in this area believed that CASE tools enforced constraints that inhibit their very existence. Because of the inherent diversity in systems design, automated tools must provide two kinds of flexibility: they must tailor a general methodology to a specific application and they must be flexible enough to allow differences in technique [Charles Martin, 1988].

Research done in 1986 by International Data Corporation revealed that the CASE products supporting analysis, design, and planning were only a small portion of the full scope of potential software engineering products [Acly, 1988]. The study showed that, though the majority of vendors currently producing CASE tools concentrated in the three life cycle areas mentioned above, the future products will include application-development and maintenance environments that address all the phases of the systems development life cycle.

One recent term--computer-aided development and maintenance environments (CADME)--was coined to describe and model the direction of the product evolution. The software products supporting development and maintenance efforts stressed two main areas: the need for stability within the development and maintenance environment and the need for an integrated approach when utilizing various tools targeted for these environments. The architecture supporting these types of products provided a three-stage schema: the conceptual model, viewing the organization as a whole and then providing specifications for data from a business viewpoint; the intermediate level, viewing the requirements of an individual or function and using a logical subset of the data described in the higher schema; and the internal model, viewing the physical definition of the data structures and determining the required access methods.

In a recent study on CASE software usage [Necco, Tsai and Holgeson, 1989], a survey instrument was developed to ". . . gain insights into the extent that organizations are using CASE tools and the types of results being attained." One hundred companies were selected from the Directory of Top Computer Executives to receive the questionnaire; 63 per cent of those selected responded. In this sample only 24 per cent of the organizations returning the questionnaire indicated that they used various types of software to automate the analysis and design phases of systems development. Of those that did use an automated tool, 100 per cent indicated that they achieved some productivity and quality gains from the product selected. Of the factors listed as elements that influenced productivity and quality improvements, 100 per cent of the respondents indicated that most improvement was achieved in the documentation developed in the systems analysis and design (front-end) processes. A majority also indicated that improved project standards resulted from usage of the CASE product.

Several researchers have emphasized that CASE tools provided automation for portions of structured systems development methodologies but were not methodologies in and of themselves. "CASE systems simply provide more effective ways of employing methodologies and techniques in an integrated and automated fashion" [Gibson, Snyder and Rainer, 1989]. Although such CASE proponents stressed the advantages of automation, they often overlooked the necessity for discipline and close management when applying the tools. "Effective software development requires a structured environment and that structure demands discipline" [Gibson, Snyder and Rainer, 1989].

One research effort attempted to identify factors that led to unsuccessful experiences with CASE systems [Norman, Corbitt, Butler and McElroy, 1989]. The research suggested that much of the failure of CASE was due to the proposition that CASE encompassed a methodology and philosophy that fundamentally changed the work process of systems development. Thus, the implementation of CASE tools was not simply a matter of providing an automated product; it was a complex problem of introducing organizational change. For their study they developed a CASE Survey Data Form to be given to an MIS department of 280 employees, 50 of whom were already active CASE users. The results were both positive and negative. They found that the factors producing the greatest negatives to using CASE tools generally fell within three categories: CASE forced people to change the way they accomplished their tasks; it caused structural changes in design output due to the enforcement of methodological standards; and, it altered the way people developing systems interacted with one another.

Interviews were conducted with CASE vendors and users to determine attitudes toward the products [Synders, 1987]. Several managers, including Vaughan Merlyn with Merlyn Consulting, viewed CASE tools as incorporating underlying methodologies that " . . . are as much about information resource management and information design as software design." Merlyn emphasized the term "engineering," an implication for discipline and standardization. Grochow, from the American Management Association, saw CASE tools being considered by large organizations (generally 1,000 people on staff); being purchased for only a small number of users (about 10 per cent of the staff); and, ". . . after the first round of enthusiasm,. . ." being shelved to collect dust. Although not formally tested, he believed that one reason for this lack of use was the requirement that personnel modify the way they performed their jobs when using CASE, resulting in a "resistance to change."

The need for greater productivity in system development led to the introduction of formal development methods in the late 1970's and early 1980's [Chilkofsky and Rubenstein, 1988]. Through the use of diagrams analysts built systematic descriptions of logical (functional) and physical (implementation) aspects of an information system. Many variations of the formal methods were developed; and though proclaimed to improve development, their general use and acceptance were limited by the manual nature of these techniques. With the inception of CASE, however, the manual diagramming methodologies were replaced with automated techniques. The system developer chose from at least seven basic diagram types--including data flow diagrams, structure charts, entity-relationship diagrams, logical data models, and presentation graphics--depending on the CASE product selected.

Many of the products marketed supported multiple methodologies. However, as Chilkofsky and Rubenstein acknowledged, to be successful the CASE environment must conform to the organization and the project rather than requiring the project to conform to the tool. The authors stated, "The CASE environment needs to be customizable so the user can adapt it to closely fit the organization's development method, project-management standards, and information requirements." Such a statement must be assumed to be the beliefs and the intuitions of the authors since no study was cited [Chilkofsky and Rubenstein, 1988].

The selection and implementation of the CASE software was viewed as paralleling the design and implementation of any management information system within an organization. The developers were the users of the system and their resistance or acceptance of it depended on various factors. Management information systems departments have historically been faced with unsatisfied users and unsuccessful projects. Because of this fact, researchers have studied factors deemed responsible for unsuccessful systems.

In one research effort the current practices of systems analysts and designers were studied to determine where failures and successes existed [Necco, Gordon and Tsai, 1989]. Four of the primary reasons they uncovered for systems failure (defined here as resistance or dissatisfaction of the user to the system) were:

1. the systems did not meet the users' requirements;
2. the systems exceeded the estimated time schedule;
3. the benefits resulting from the systems did not compensate for the resources expended; and
4. the systems were excessively difficult to use and costly to maintain.

They further questioned users to determine those key factors that would improve the development and acceptance of management information systems. The five most important factors were:

1. management support and involvement;
2. user involvement;
3. improved training and education on system;
4. reliability; and
5. ease of understanding and use.

Another study done in 1989 concentrated on the issue of user involvement and the acceptance of the system [Barki and Harwick, 1989]. They agreed with a previous study [Patchen, 1970] indicating that job interest was increased by high difficulty, high control over the means of work, and high feedback. Both of these research efforts suggested that meaningful participation was an important antecedent of involvement and involvement was an important antecedent of acceptance.

In MIS Quarterly one author concurred with the statement made by Land in 1982 that the "most critical stage for analyst and user interaction occurs in the problem definition and requirements stage" [Green, 1989]. Without strong user involvement, Green found an increased liklihood that users would resist implementation efforts of a new system, even when the system was considered useful. This finding has been supported in several previous studies [Argyris, 1971; Bostrom and Heinen, 1977; Lucas, 1975].

Summary

This review of the literature suggests that CASE products have been generally accepted as providing increased productivity and improved quality for the systems designers and analysts using them. However, studies showed a continued hesitancy among information systems management to purchase CASE products for their systems development staff. One reason given for not installing CASE products was the high resource expenditure required to provide these tools. One other issue that surfaced as a management concern was the non-use of the CASE product even when the product was available to analysts. Before management can feel confident about installing the product, they must better understand the causes of the resistance to the product. Therefore, an effort is required to determine what factors affect this resistance.

Several researchers indicated that the issue of standards, including their importance to the development effort prior to the use of CASE systems, was felt to be a significant factor affecting the analysts' resistance to the use of the tools. To date, no study had been done on the possible relationship between the a priori enforcement of standard methodologies and the implementation of CASE tools. This research was designed to consider this possible relationship. The following chapter discusses the research approach used to gather data and analyze this issue.

RESEARCH METHOD

The first section of this chapter details the research design. The second section of the chapter discusses the data analysis procedures.

Design

Companies selected for this survey were limited to those developing a minimum of two major projects during a twelve-month period. For this study, a major project was defined as one that extended over a period of two months from the initial user requirements phase through the installation phase of the systems development life cycle.

A survey instrument was designed and mailed to 151 information systems departments, each with currently active systems development areas and with full-time staffs employed in the systems development and programming areas. These organizations were selected from a variety of directories that provided the name and title of personnel employed in information systems operations for individual organizations. The source of these directories included two professional information systems organizations: the Data Processing Management Association and the Association for Systems

Managers. Only one survey instrument was mailed to a particular department within an organization, although some few companies that housed multiple IS departments received questionnaires for each of the individual departments.

The survey instrument, along with an accompanying letter and a stamped, self-addressed envelope, was mailed to each of the 151 recipients (See Exhibit A and Exhibit B in the Appendix). The letter explained the purpose of the research and requested that either a systems analyst, designer or developer within the information systems department respond. This request was meant to target the senior members of the staff as respondents. For those respondents who wished results of the survey returned to them, a name and address slip was enclosed. Fifty-four of the 76 usable returns requested follow-up results.

The questionnaire had three categories of requested information. In the first category, the respondent was requested to supply information as to the number of employees within the information systems department, the number of years the organization has had an information systems department in place, the number of systems developed within a twelve-month period of time, and the average level of experience for the systems analysts and programmers. Some rudimentary efforts were also made to gather information as to the types of systems methodologies and developmental tools and techniques the analysts had used.

The second category of questions concerned the issue of systems development standards. The instrument attempted to discern whether there was currently a set of enforced standards in the systems design and development phases of the systems life cycle. If such standards were enforced, further efforts were made to determine the length of time the organization had been enforcing these standards, the degree to which the standards were enforced, the specific types of methodologies employed, and the phases of the systems life cycle in which the standards were used.

The third area of requested information attempted to gather data about whether or not the organization had implemented any CASE tools for use in their front-end or back-end systems development efforts. If CASE systems were being used, further information was solicited.

Besides gathering information concerning the type of product, the product-supported methodology, and organization-supported methodology, an effort was made to determine whether the organization allowed users (analysts and designers) to participate in the product selection process. This particular line of questioning was deemed important since previous research had reported that such user involvement was necessary for the overall acceptance or success of a system [Green, 1989].

Along with information about the product selection, questions were asked concerning the types of training offered to analysts and designers with the implementation of the product and whether the training was satisfactory. Also, specific questions were asked concerning the methodology used by the analysts before implementation of the automated tool and whether any consideration was given to this previous experience when the CASE tool was selected.

For those companies not using CASE products, the respondent was queried as to the reasons for this non-use. An effort was made to determine whether any CASE product had been previously used or tested. No futher questions were asked of these non-CASE users.

The accompanying letter requested that the organization return the survey instrument within a three-week period. For those organizations not returning the questionnaires four weeks from the date of mailing, a follow-up mailing or telephone call was done. After a period of six weeks had elapsed, those who had not returned the survey instruments were assumed to be excluded from this sample.

A 33 per cent response rate, representing a return of approximately 50 instruments, was expected. Because those organizations selected for this survey represented some of the larger companies within the Middle Atlantic states, the sample was not a simple random sample of data processing departments but, rather, a clustered sample of some of the largest and most financially sound organizations within the area surrounding Richmond, Virginia. Because CASE systems represent a reasonably large expense to the organization, such a selection was deemed necessary since only those organizations that had selected and implemented CASE systems were included in this research effort.

Data Analysis

Prior to the mailing of the survey instrument to the designated organizations, a pretest was made at three information systems departments within the Richmond area. Two of the three respondents were currently using a CASE tool; the other was not.

After completing and returning the survey instrument, each respondent was queried as to his or her response to the questions and the level of understanding of the meaning of the questions. One respondent made a suggestion that the cover letter be more explicit as to whether the respondent was answering for himself or herself or for what he or she felt was the department's response. To minimize any confusion, a statement was included in the cover letter instructing the respondents to answer according to their individual feelings and attitudes. Neither of the other two respondents submitted any suggestions for improvement.

Once the survey instruments had been sent, collected, and recorded, various analyses were run against them to determine whether the original assumptions of size of department and frequency of development activity were indicators of the availability of a CASE tool. Following these initial analyses, the respondents were grouped into two major categories: those that had installed CASE products and those that had no such products. All analyses were performed from the group with CASE products.

This sample group of CASE users was then divided into two groups: those who developed information systems with enforced methodological standards and those which did not enforce any specific methodological standards. Each of these two major groups were then further divided into subgroups.

The groupings and their subordinate groupings used for this research were defined as:

1. those organizations that enforced standards before CASE tools were selected and implemented:
    a. those organizations using the same systems development methodology both before and after the implementation of CASE;
    b. those organizations using a different systems development methodology before the implementation of CASE than they used after the implementation of CASE.
2. those organizations that did not enforce standards before CASE tools were selected and implemented:

a. those organizations providing specific education in the methodology used by CASE along with instruction as to how to use the software product;

b. those organizations providing training on the CASE product but not on the specific methodology used.

After these four groups had been formed, an effort was made to compare responses to determine whether there was a significant difference between the various groups concerning the respondents' satisfaction and use of the CASE products.

Conceptual Model

An analysis of variance was run to determine the probability of a significant relationship between the independent variables and the dependent variable in three separate situations. These situations were:

a. those that had a priori methodological standards versus those that did not have such standards;

b. for the subgroup that did have a prior standards, a further comparison between those that used the same methodological standards both before and after the CASE tool was implemented versus those who used a different methodology after the installation of CASE; and

c. for the subgroup that did not have methodological standards prior to CASE installation, those that received training on the CASE product and the methodology versus those that received training only on the product.

A ratio of variance was employed in all three situations to establish whether the means differed between the various groups. The level of significance was determined by computing an f-ratio for the difference of means test.

The null hypothesis assumed that the two sample means under scrutiny were equal; the formal assumption was made that the variances between the two groups were equal in the two samples from which the two sets of observations came. The proposed models of variance were:

$$\text{Variance} = \frac{n^1 - 1}{n_1 + n_2 - 2} s_i^2 + \frac{n_2 - 1}{n_1 + n_2 - 2} s_j^2$$

The f test used was:

$$t = \frac{\bar{y}_i - \bar{y}_j}{s\sqrt{1/n_1 + 1/n_2}}$$

where $n1$ was the number of observations in one group;

$n2$ was the number of observations in the other group;

s_i^2 was the variance of the first group;

s_j^2 was the variance of the second group;

$\bar{y}_i$ was the mean of the first group;

$\bar{y}_j$ was the mean of the second group.

The ANOVA model used was:

$$Y_{ij} = u_j + E_{ij}$$

The initial analysis used a two-factor model because there were two independent variables: the existence of _a priori_ methodological standards and the inclusion of the analyst in the selection of the CASE tool. These were classification, qualitative factors since the characteristics of the units under study were not under the control of the investigator and were not quantitative.

A random effects model, Model II, was used since the conclusions of this study extended to a population of factor levels of which the levels in this study were a sample. Both factor A effects (A_i) and factor B effects (B_j) were assumed to be random variables. The sample distribution for the dependent variable and all factor levels were assumed to yield equal variances. Study results were generalized to include those outside the sample being surveyed.

Table 1. The ANOVA Table for this study.

Two-Factor CASE Acceptance Study

(a) Acceptance/Resistance to CASE tools

	a priori Standards (factor B)	
Included in Selection (factor A)	Yes ($j = 1$)	No ($j = 0$)
Yes ($i = 1$)		
No ($j = 0$)		

(b) ANOVA Table

Source of Variation	SS	df	MS	E(MS)
A	$SSA = b\sum(\bar{Y}_{i.} - \bar{Y}_{..})^2$	$a-1$	$MSA = \frac{SSA}{a-1}$	$^2 + \frac{b}{a-1} a^2_i$
B	$SSB = a\sum(\bar{Y}_{.j} - \bar{Y}_{..})^2$	$b-1$	$MSB = \frac{SSB}{b-1}$	$^2 + \frac{a}{b-1} B^2_j$
Error	$SSE = \sum\sum(Y_{ij} - \bar{Y}_{i.} - \bar{Y}_{.j} + \bar{Y}_{..})^2$	$(a-1)(b-1)$	$MSE = \frac{SSE}{(a-1)(b-1)}$	^{2}
Total	$SSTO = \sum\sum(\bar{Y}_{ij} - \bar{Y}_{..})^2$	$ab-1$		

To test the presence of factor A effects in the random effects model the following assumptions were made:

$$C_1 : \sigma^2_a = 0$$
$$C_2 : \sigma^2_a \neq 0$$

The assumptions made to test for factor B effects were:

$$C_1 : \sigma^2_B = 0$$
$$C_2 : \sigma^2_B \neq 0$$

The independent variables in this study included the existence of a priori methodological standardization, the degree of education and training on the product, and the level of user involvement in the selection process. The dependent variable was the level of resistance to the CASE product. For this research, resistance to the product was measured by whether the product was selected for use.

The first analysis was tested with two degrees of freedom; the other two analyses, with one degree of freedom. All returned data from CASE users were collected and summarized in presentation form.

The model proposed in this study suggested that each observation be decomposed into three additive terms:

observation = overall mean
\+ deviation of group mean from overall mean
\+ deviation of observation from group mean.

This model agrees with the general assumptions of analysis of variance [Iversen and Norpoth, 1976].

Summary

This research effort was designed to determine whether there was a relationship between the acceptance and use of a CASE product and the existence of enforced a priori standards. Two additional issues were considered. The first issue concerned only those departments that enforced a priori standards; it analyzed whether retention of the identical methodology both before and after CASE implementation affected the acceptance and use of the product. The second issue concerned those installations without a priori standards; it analyzed whether training in the methodology along with the CASE product affected the acceptance and use of the product.

To determine whether significant relationships existed, the CASE user responses were evaluated through an analysis of variance and tested at the 95 per cent level of confidence. The following chapter discusses the results of these data analyses.

DATA ANALYSIS AND RESULTS

An analysis of the survey data, reflecting the attitude of CASE users concerning their acceptance and use of the Computer-Aided Systems Engineering product, is presented in this chapter. The survey instrument that was used consisted of twenty-four questions (See Appendix A). The analytical process that was selected for the analysis compared the means of paired samples.

Much of the information derived from the analyses is presented in tabular form in order to facilitate review, evaluation, and conclusions. A discussion of these analyses immediately follows a brief description of the total sample from which the various independent samples were taken. Subsequently, each variable representing an hypothesis is discussed individually. These discussions report on the nature of the samples and the results of the statistical tests, present the decision of the null hypothesis, and interpret and draw conclusions from the findings.

The Research Sample

The survey sample consisted of selected organizations within the states of Virginia, North Carolina, Maryland, and

Ohio that were believed to maintain a full-time, active information systems departments large enough to develop a minimum of two major projects within a twelve-month period. For this research a major system project was defined as one that extended over a minimum of two months. Mailing lists from regional Data Processing Management Associations and the Association of Systems Managers were the sources for the employee names and organization addresses selected for this research.

Each question on the instrument was scaler allowing a variety of responses from 1, representing the least or lowest degree of response, to 7, representing the greatest or highest degree of response. This type of scale was proposed by Likert in his management research, as he felt that it reduced or eliminated the high intercorrelations apparent on other types of survey response choices [Likert, 1967]. Of the various psychological measurement methods used to assess human judgment, rating scale procedures have been the most widely used [Guilford, 1954]. According to Moskowitz, such scales have been conceptually simple for the experimenter and the respondent and appeared to yield valid, quantifiable data that reflected a general level of feeling about a particular subject [Moskowitz, 1983].

To assess the validity of the instrument, a pretest was given to three subjects. Two of the three respondents were currently using a CASE tool, the other was not. After completing and returning the survey instrument, each respondent was queried as to his or her response to the questions and the level of confidence with which the questions were answered. All suggestions made were incorporated into the survey instrument and/or the cover letter prior to mailing.

A total of 151 survey instruments were mailed, along with cover letters (See Appendix B); enclosed, stamped, self-addressed envelopes; and forms to be returned should the respondents wish to have copies of survey results returned to them. Usable responses on the survey instruments were necessary for a subject to be included in the research sample. Seventy-eight instruments were returned; one of these was returned due to "Addressee Unknown" and one unanswered response was returned with an accompanying note stating that there was no CASE used in the organization. The remaining 76 responses represented a 50.033 per cent return rate. Of these 76 respondents, 39 (or 51.3 per cent) used some type of CASE product.

The computer package used to summarize and analyze the data was STAT-PAK, a statistical package developed by Northwest Analytical, Inc., Portland, Oregon. Several statistical procedures were utilized from this package, including the descriptive statistics, that measured the mean responses and variances of the selected questions, the table and bar graphics of the frequency distributions, and the

ANOVA and multiple range tests applied to the pairs of independent sampled data.

Examination of the Variables

The Test Procedure

The test instrument requested responses in three different categories of information. The first category requested information concerning organizational and departmental status and function; the next area concentrated on the use of methodologies and standards; and the third category asked questions concerning the use of a CASE product. Initially, some basic descriptive statistics were run on the organizational- and departmental-level responses to determine the characteristics of the research sample. The first three questions concerned the information systems department within the company and asked questions relating to such data as the number of full-time employees, the number of major systems developed within a twelve-month period, and the number of years the company has staffed an information systems department. One additional question queried the respondent as to his or her specific job title.

Next, several questions were asked concerning the level of standardization and the types of methodology used within the company. These questions requested responses from both the CASE users and the non-users. Another question concerned whether the company had a CASE tool available for the systems design and development staff to use; a NO response to this question allowed the respondent to stop at this point.

The remaining 16 questions on the survey instrument concerned information about the CASE product. Several questions queried the respondent as to the extent he or she used the product and the overall satisfaction with CASE. Of primary importance was whether the organization required the use of CASE in the system design and development effort and whether the respondent would elect to use CASE if he or she was not required to do so. Additional questions concerned the degree of input the respondent had in the selection of the product, the amount of training provided by the organization on the product, and the amount of education provided on the methodology selected.

The research sample consisted of all returned, usable responses. This sample was then divided into two groups: those who had a CASE tool to use for design and development purposes and those who did not have access to such a tool. The primary file used for the remaining analyses consisted of the 39 CASE users.

The CASE users were initially divided into two subgroups: those who were satisfied with the CASE product and those who were not. An analysis of variance was then run to determine whether there was a significant relationship between the satisfaction to the product given two other factors: input to the selection of the product and a priori standardization of methodologies. Mean scores were calculated for each sample and served as the basic unit of comparison. Each pair of means was compared by the use of the t test and the multiple range program F ratio to determine the extent to which the pairs differed. The decision criterion was then applied to the resulting F value to determine whether the difference was significant in terms of the required level of confidence.

Report of the Results

To ensure reliability in the instrument, the four specific issues most closely evaluated were asked in at least two different ways. Specific issues dealing with the use of a standard methodology and its enforcement of standards were included in questions 7 and 12; for the issue of input into the product selection, questions 9 and 20; for the issue of familiarity with the methodology, questions 15 and 21; and for the area of level of satisfaction with CASE, questions 11, 18 and 24. Descriptive statistics were run against each set of these responses to determine how closely the responses approximated one another. In all four sets of responses the means were within one standard deviation of one another. See Table 2 for more detail.

Table 2. Reliability Testing for the Sets of Questions Concerning the Issues of A Priori Standardization, Input to Selection of Product, Familiarity with Methodology, and Level of Satisfaction with CASE.

	Mean Score	Standard Deviation	Variance
STANDARDIZATION:			
Question 7	3.70270	2.05156	4.26891
Question 12	4.15384	2.11476	4.64299
INPUT TO SELECTION OF PRODUCT:			
Question 9	3.16667	2.33928	5.47222
Question 20	3.85294	2.43904	5.94896
FAMILIARITY WITH METHODOLOGY:			
Question 15	4.26315	1.95588	3.82548
Question 21	3.42857	1.74496	3.04489
LEVEL OF SATISFACTION:			
Question 11	4.68293	1.93099	3.72873
Question 18	4.58065	1.82764	3.34071
Question 24	4.91666	1.89113	3.57638

n = 76

Each set of findings was treated independently. The findings were reported as they related to a specific hypothesis, the background aspects of the samples chosen, interrelationships between the variable under primary consideration and other variables, and the results of tests of hypotheses. Each section was concluded with an interpretation and discussion of the findings.

Demographic and Historical Data

Some personal, organizational, and historical data was collected to determine the overall characteristics of the research population. The information was obtained through several introductory questions on the survey instrument.

For the entire seventy-six respondents to the question of in-house personnel, the most often marked response was either 2 or 3, indicating that most of the departments queried had a range of 5 to 99 full-time employees within their information systems department; the standard deviation for this question was 1.6 (see Table 3). When the respondents were divided into the non-CASE versus the CASE users, the results differed. The response of 2, which was marked most often for the thirty-seven non-CASE users, indicated a range of 5 to 49 full-time employees and a standard deviation of .9. For the thirty-nine CASE users, however, the response given most often was 3, indicating

Table 3. Demographic and Historical Data Relating to the Respondents

Question	1	2	3	4	5	6	7	n
	Actual Numbers							n
How many full-time systems analysts... work in IS/DP dept of your org.?	< 5	5-49	50-99	100-149	150-199	200-249	> 250	
Answers:								
Non-CASE Users	14	19	3	0	0	1	0	37
CASE Users Only	6	17	4	5	1	0	6	39
Total Sample	20	36	7	5	1	1	6	76
How many systems... were produced in your dept during the last 12 months?	< 2	2-4	5-9	10-14	15-19	20-24	> 25	
Answers:								
Non-CASE Users	11	11	9	5	0	0	1	37
CASE Users Only	3	11	11	6	3	0	5	39
Total Sample	14	22	20	11	3	0	6	76

Table 3. Demographic and Historical Data Relating to the Respondents (continued)

Question	1	2	3	4	5	6	7	
	Actual Numbers							n
What is your job Title?	Dir	Mgr	Supr	Anlt	Sys/Cpr Pgr	Anlt/ Pgr	Other	
Answers:								
Non-CASE Users	10	12	2	2	4	1	6	37
CASE Users	4	14	2	6	3	1	9	39
Total Sample	14	26	4	8	7	2	15	76
How many years has your organization had an IS/DP Dept?	<5	5-9	10-14	15-19	20-24	25-29	>30	
Answers:								
Non-CASE Users	3	6	5	6	10	3	4	37
CASE Users Only	3	3	1	7	8	5	12	39
Total Sample	6	9	6	13	18	8	16	76

that these departments had a range of 50 to 149 full-time employees and a standard deviation of 1.9 (see Table 3). From this random sample it appeared that those departments with CASE tools tended to employ larger numbers of people than those departments without the tool.

Responses 2 and 3 were the ones most often marked regarding the number of major systems the IS department designed and developed over a twelve-month period indicating a range of 2 to 9 systems. The standard deviation was 1.6 (see Table 3). The response for numbers of systems being developed by non-CASE users was slightly lower than for the entire file. This was accompanied by a lower standard deviation of 1.3. However, for the CASE users the responses marked most often indicated that their departments designed and developed between 5 to 14 systems, with a standard deviation of 1.7. (See Table 3.) Once again it appeared that those departments that developed more systems tended to use the CASE product more often than their counterparts.

To the question concerning the number of years the department had been established within the company, the seventy-six respondents indicated a 15- to 24-year operating facility, with a standard deviation of 1.89 (See Table 3).

Standardization and Methodology Data

Specific comparisons that appeared interesting between the CASE user group and the non-CASE user group concerned standards and methodologies. These questions were designed to compare the responses of the CASE-user group and the non-CASE-user group concerning methodology and enforced standardization.

When queried whether there was a company-imposed standard methodology used in the systems design and/or development process, the non-CASE users' mean response was 2.7, signifying a response closer to the NEVER scale anchor (see Table 4). The CASE users' mean responses concerning methodological standards was 4.3, almost exactly midpoint on the scale, with a coefficient of variation of 36.95 (See Table 4). Such results suggested that analysts with CASE products conformed to a specific methodology more often than analysts without CASE tools.

Concerning the issue of enforced standards, the non-CASE users' mean response was 2.7, closer to the NEVER scale anchor response; the coefficient of variation was 64.56 (See Table 4). The CASE users' mean was 4.1 with a coefficient of variation of 43.16 (See Table 4). Both of these categories suggested that the CASE users generally had standards more stringently enforced than did non-CASE users.

Several other responses appeared relevant to this research. When asked about satisfaction with the training on CASE, the statistical mean response was 4.19, almost

Table 4. Standardization and Methodology Responses

Question	Responses 1	2	3	4	5	6	7	n
	Actual Numbers							
Does your org require the use of 1 or more standard methodologies . . . during systems development?	Never						Always	
Answers:								
Non-CASE Users	12	9	7	3	2	1	3	37
CASE Users Only	2	3	7	9	8	7	3	39
Total Sample	14	12	14	12	10	8	6	76
How strictly are these standards enforced?	Never						Always	
Answers:								
Non-CASE Users	13	6	6	5	3	3	1	37
CASE Users Only (2 did not respond)	3	5	6	5	7	8	3	37
Total Sample	16	11	12	10	10	11	4	74

midway on the scale. Thus, companies with CASE tools appeared to train personnel adequately (See Table 5).

When asked whether the respondent utilized the same methodology before and after installation of the CASE product, respondents chose answers almost midpoint on the scale, indicating a mean response of 4.70 (See Table 5). From this it appeared information systems departments were not concerned with retaining like methodologies.

Finally, to the question concerning whether the CASE tool was helpful in the performance of the analyst's job, respondents selected answers slightly higher than the midpoint, indicating a mean response was 4.92 (See Table 5). These respondents demonstrated a positive overall acceptance to Computer-Aided Systems Engineering product.

Discussion of Null Hypotheses

Hypothesis 1 - Enforcement of Standards

There is no significant difference in the usage of CASE systems between those companies that enforced systems standards before the CASE tool was implemented and those companies that did not have previously enforced standards.

Background

The research compared the effect *a priori* enforced standards had on the acceptance and usage of the CASE tool

Table 5. Responses Concerning Training, prior Methodological Knowledge and Overall Helpfulness of CASE.

Question	Responses 1	2	3	4	5	6	7	
	Actual Numbers							n
Did you use the same methodologies before and after CASE product was selected?	Never						Always	
Answers:								
CASE Users Only	5	3	3	6	7	8	4	36
How satisfied were you with training?	Not Satisfied						Completely Satisfied	
Answers:								
CASE Users Only	7	7	2	3	7	0	9	35
How helpful is CASE in development?	Not at All						Extremely	
Answers:								
CASE Users Only	1	4	2	4	5	12	7	35

by the systems designer/developer. Based upon the review of the literature, there appeared to be some relationship between the existence of such a priori standards and the overall usage of the product. Because this approach necessarily limited responses to departments that had previously adopted a CASE package, those respondents who did not answer the CASE-oriented section of the instrument were eliminated from further analysis.

Characteristics of the Sample

The means of the variables in the study relating to a priori standards and usage of the CASE product were subjected to the t test to determine if they differed significantly from those that did not have such standards in place before product installation.

Before running the 39 responses through an analysis of variance, those questions selected (Questions 7, 9 and 11) with responses ranging from 1 to 7 were collapsed into Yes or No answers. The use of a seven-point scale in business and social science research has been widely accepted [Ferber and Verdoorn, 1970; Dixon and Massey, 1983; Festinger and Katz, 1953]. Research conducted on the Job Analysis and Interest Measurement test used both a seven-point scale, a conversion to 0 or 1 responses and an analysis of variance [Walther, 1972], similar to the types of analyses done in this research.

Because an analysis of variance required a 0 (NO) or a 1 (YES) answer, the responses on the survey instrument were converted from the 1 to 7 range into a 0 or 1. In order to accomplish this, frequency distributions for the questions dealing with standardization, level of usage, and satisfaction level with the CASE tool were computed. Justification for using this method as a preliminary step to the variance analyses has been referenced in various publications [Dixon and Massey, 1983; Miller, 1976]. The authors suggested that the distribution of the mean, standard deviation, and variance of any random selection within the sample should approximate the mean, standard deviation, and variance of the full sample; any significant differences resulting between the full sample and any subsamples indicated that these subsamples were not members of the same sample and provided the point of division for the analysis of variance.

Using this principle, the standard deviations and variances were calculated for each question to be analyzed. The mean was not used, since one subsample consisted of low-numeric values and the other of high-numeric values. Thus, only the standard deviations and variances were used for comparison in this research.

A frequency distribution was computed on the original responses and displayed in a histogram. This provided the initial point to test for two divisions, Yes and No, within the full sample. After this first test, the interval points immediately above and below the original division point were tested. This process continued until standard deviations and variances had been computed for all test groups. The groupings that offered the greatest difference in the standard deviation and variance from the full sample were selected as the division points for each question analyzed.

For example, if the distributions displayed a visual segmentation of responses between responses 2 and 3, several tests were run at and approximating this point. Initially, the original responses were divided into two separate groups, with responses 1 and 2 in one group and the remaining responses, 3 through 7, in another group; standard deviations and variances were calculated and compared to those of the full sample.

A second test was then run, segmenting response 1 from the remaining responses, 2 through 7, and calculating the same two measurements; these were then compared to the like measurements of the full sample. This process of dividing the original responses into two groups and subsequently calculating the standard deviations and variances continued until a group reached the highest point of difference when compared to the full sample. Additional test groups resulted in a decrease in the difference. The division providing the greatest difference between the standard deviation and the variance when compared to the full sample represented the point where the two subsamples separated into 0 and 1 groups. These frequency distributions and the calculations of standard deviations and variances are provided in Exhibits 1 through 7. The specific questions asked and the results of the analysis of variance were as follows:

1. <u>Question 7</u>. Did the company require the use of one or more standard methodologies. . . prior to installation of the CASE tool?

The 39 CASE users who answered this question provided a mean score of 3.70 with a variance of 4.326 and a standard deviation of 2.089. The resulting statistical mean score in the distribution was 3.66 given an interval of .666667. Responses 1 and 2 were converted to a 0 (NO) response; anything above 2 was converted to a 1 (YES) response (See Exhibit 1).

2. <u>Question 9</u>. How involved were you in the evaluation and selection of a CASE tool?

The mean score was 3.211 with a variance of 5.792 and a standard deviation of 2.407. The resulting statistical mean score in the distribution was 3.6667 given an interval of .666667. Responses 1 and 2 were converted to a 0; other responses were converted to a 1 (See Exhibit 2).

3. <u>Question 11</u>. If the tool used is/were voluntary, how often would you use it to design and develop systems?

Of the total responses to this question, the mean score was 4.816 with a variance of 3.722 and a standard deviation of 1.930. The resulting statistical mean score in the frequency distribution was 4.333 given an interval of .666667. Responses 1, 2 and 3 were converted to a 0 (NO) response; anything above 3 was converted to a 1 (YES) response (See Exhibit 3 in the Appendix).

After responses were converted to 0 and 1, a new file was produced. This was the file used in the analysis of variance.

The first analysis concerned the satisfaction the user felt with the CASE tool as being a function of whether the standards were enforced _a priori_ to the installation of CASE (S) and whether the respondent had some input into the selection of the product (I).

$$\text{Satisfaction} = f(S, I)$$

Test Results

The statistical findings from these analyses are summarized in Table 6 (a), Table 6 (b), and Table 7. Table 6 (a) includes the difference of the means as well as the resulting t value for differences between the means concerning the usage (satisfaction) of the product (Question 11) and the enforcement of _a priori_ standards

Table 6 (a). Satisfaction with CASE and a priori Standards

	Question 11 n=39 Satisfaction	Question 7 n=39 Standardization
Mean Score	0.7180	0.5946
Standard Deviation	0.4559	0.4978

Difference of the Means	0.1234
Standard Error of the Difference	0.0774
f value	1.2713
Significance Level	0.2631

Table 6 (b). Satisfaction with CASE and Input to Selection of Product

	Question 11 n=39 Satisfaction	Question 9 n=39 Selection Input
Mean Score	0.7180	0.4500
Standard Deviation	0.4559	0.5038

Difference of the Means	0.2679
Standard Error of the Difference	0.0765
f value	6.1339
Significance Level	0.0155

(Question 7) for CASE users. This value does not reflect results of a test of hypothesis but rather serves to indicate which of two computations of t to use. Table 6 (b) shows the results from the ANOVA that analyzed satisfaction with CASE, standardization, and input allowed in the selection of the product. Since the f value was above the critical value for significant difference in variance at the .05 level, the variances about the means were interpreted to be sufficiently different. For this relationship the F ratio was 3.006 with significance at 0.0534.

The multiple-range program also provided an F ratio. This test calculated a difference of 0.1234 between the satisfaction and standardization results and showed a significant difference at the .05 level. A difference of 0.26798 was calculated between the satisfaction and input to the product selection results and showed a significant difference at the .05 level. Both treatments individually compared proved above the .05 level of significance.

Table 7 includs the F value computed from the means concerning the usage of the product (Question 11) and the input to selection (Question 9). Since the calculated F ratio exceeded the critical value for significant difference in variance at the .05 level, the variances about

Table 7. ANOVA for Satisfaction with CASE and *a priori* Standards

	Question 11 n=39 Satisfaction	Question 7 n=39 Standardization	Question 9 n=39 Selection
Mean	0.7179	0.5946	0.45
Std Error	0.0730	0.0818	0.0797

Standard Error of Treatment Means	0.067966

	Difference	Sig .05
Satisfaction vs. Standardization	0.1234	Yes
Satisfaction vs. Selection	0.2679	Yes
Standardization vs. Selection	0.0145	No

F test ratio = 3.0064
Significance = 0.0534
Degrees of Freedom = 1

the three means were interpreted to be sufficiently different. The F ratio was 5.361056 with significance at 0.0066.

Hypothesis 2 - Difference in Methodology

For those companies with enforced standards prior to CASE, there is no significant difference in the usage of CASE systems between those companies that imposed a methodology standard different from the one imposed after CASE implementation versus those companies that imposed the same methodology both before and after CASE installation.

Background

The research considered the effect a change in the methodologies used before and after CASE installation might have on the acceptance, i.e. usage, of the CASE tool by the systems designer/developer. This analysis was limited to responses from those companies that had adopted a CASE package and had *a priori* standards in place before implementing the product.

Characteristics of the Sample

The means of several variables were subjected to the t test to determine if they differed significantly for samples established for the evaluation of standardization. In most instances, the sample means did not differ appreciably.

To successfully run the responses through an analysis of variance, the indicated questions for this analysis (Question 11 dealing with satisfaction and question 15 dealing with use of the same methodology before and after the installation of CASE) had responses ranging from 1 to 7, as specified by Likert-scale criteria. These responses initially had to be converted to either a 0 (NO) or a 1 (YES) answer. In order to decide the division point for these responses, frequency distributions for the questions dealing with standardization and usage were run and possible division points were determined. Dividing the responses into two separate groups, calculating the standard deviations and variances, and comparing these measurements against those of the full sample provided the specific point at which to break the two groups. The specific questions and the results of the analyses are as follows:

1. Question 11. If the tool used is/were voluntary, how often would you use it to design and develop systems?

Of the 38 responses used for this comparison, the mean score was 4.816 with a variance of 3.722 and a standard deviation of 1.930. The resulting statistical mean score in the frequency distribution was 4.333 given an interval of .666667. Responses 1, 2 and 3 were converted to a 0 (NO) response; anything above 3 was converted to a 1 (YES) response (See Exhibit 3).

2. Question 15. Did you use the same methodologies before and after the CASE product was selected?

Of the 38 CASE-user responses to this question, the mean score was 0.68421 with a standard deviation of 0.4711. The resulting statistical mean score in the frequency distribution was 3.6667 given an interval of .666667. Therefore, responses 1 and 2 and 3 were converted to a 0 (NO) response; anything above 3 was converted to a 1 (YES) response (See Exhibit 4).

Once the responses to these questions were converted to 0 and 1, an analysis of variance was run. The analysis involved only those CASE users that required standardization prior to CASE installation and considered the satisfaction the user had with CASE as a function of whether the same methodology was used before and after the installation of CASE (M).

For the CASE users with a priori standards:

$$\text{Satisfaction} = f(M)$$

Test Results

The statistical findings relating to this variable are summarized in Table 8. Table 8 includes the F value from the analysis of variance about the means and the t value relating to differences between the means concerning usage of the product (Question 11) with the responses concerning change in methodologies (Question 15). Since the F value was below the critical value for significant difference in variance at the .05 level, the variances about the two means were interpreted not to be sufficiently different. The least significant difference multiple-range test was applied to determine the equality of means. In this case the least significant difference multiple-range test produced an F ratio of 0.0608 with significance at 0.8060 (See Exhibit 5).

Hypothesis 3 - Difference in Methodological Training

For those companies that had CASE systems but did not have enforced standards prior to CASE, there is no significant difference in the usage of CASE systems between those companies that provided training in the selected methodology and those companies that provided no methodology training.

Background

The research was conceived with the idea of comparing the effect that training in the specified methodologies used with the CASE tool as well as training on the CASE product had on the acceptance or rejection, i.e. the usage, of the CASE tool by the analyst. Because this approach necessarily

Table 8. ANOVA for Satisfaction with CASE and Use of the Same Methodology both Before and After Selection of the Product

	Question 11 n=38 Satisfaction	Question 15 n=38 Same Methodology both Before and After CASE
Mean	0.71053	0.6842
Standard Err	0.07456	0.0764
Standard Deviation	0.45961	0.4711

Std Error of Treatment Means	0.0755

	Difference	Sig .05
Satisfaction vs. Methodology	0.0263	No

F test ratio = 0.0608
Significance = 0.8060
Degrees of Freedom = 1

limited the responses to those companies that had adopted a CASE package and did not have a priori standards, the file used for this analysis was a subset of the original data file.

Characteristics of the Sample

The means of several variables in the study were subjected to the t test to determine if they differed significantly for samples established for the evaluation of standardization. In most instances, the sample means did not differ appreciably.

To successfully run the 15 responses through an analysis of variance, the indicated questions for this analysis (Question 11 concerning satisfaction with the CASE product and question 17 concerning training on the methodology) had responses ranging from 1 to 7, as specified by Likert-scale criteria. These responses were converted to either a 0 (NO) or a 1 (YES) answer after determining the point of division from a series of frequency distributions and testing the standard deviations and variances between sample groups. The specific question and the results:

1. Question 11. If the tool used is/were voluntary, how often would you use it to design and develop systems?

The same responses were retained for this analysis as the previous one, although the sample size was reduced to consider only those members who responded to question 17.

2. Question 17. How much training did you receive on the supported methodologies?

Of the 15 responses to this question, the mean score was 4.333 with a frequency distribution showing a wide gap between the number of responses to 1, 2 and 3 and the number of responses for the remaining questions, 4 through 7. Responses 1, 2 and 3 were converted to a 0 (NO) response; anything above 3 was converted to a 1 (YES) response (See Exhibit 5).

Two additional analyses were run concerning training on the CASE product. Although these were not originally a part of the proposed research, it was felt that these questions might have a bearing on the overall satisfaction with the product. Therefore, the following questions were also analyzed:

3. Question 16. How much training did you receive on the CASE product?

Of the 14 responses to this question, the mean score was 3.6667 with a frequency distribution showing intermittent gaps. From the distribution, responses 1 and 2 were converted to a 0 (NO) response; anything above 2 was converted to a 1 (YES) response (See Exhibit 6).

4. Question 22. How satisfied were you with the training you received on the CASE product?

Of the 11 responses to this question, the mean score was 3.6667 with a frequency distribution showing answers scattered across the graph and no true gap. Because the response range was continuous from Not Satisfied to Completely Satisfied, the researcher felt that responses 1, 2 and 3 were below the midpoint and were thus converted to a 0 (NO) response; anything above 3 was converted to a 1 (YES) response (See Exhibit 7).

Once these 4 sets of responses were converted to the required 0 and 1 responses, the analysis of variance was run. The analysis included only those CASE users who did not have enforced standardization prior to the installation of the tool. These respondents felt that the satisfaction the user expressed with the CASE tool was a function of whether the training by the organization overcame the lack of knowledge the user felt both with the methodology and with the CASE product (T).

For the sample file of CASE users who did not have a priori standards:

$$\text{Satisfaction} = f(M)$$

Test Results

The statistical findings relating to these variables are summarized in Tables 9, 10 and 11. Table 9 concerns the analysis relating to differences between the means concerning the usage of the product (Question 11) and the training provided on the methodology (Question 17). Both an analysis of variance and the least significant difference multiple-range program was run. The F-ratio was calculated as a test for equality of means. This test produced a difference of 0.066667. Since the F value was below the critical value for significant difference in variance at the .05 level, the variances about the two means were interpreted not to be sufficiently different. The F ratio was 0.148936 with a significance at 0.7025.

Table 10 reports the analysis relating to differences between the means concerning the usage responses (Question 11) and the training provided on CASE (Question 16). In this case the F value was above the critical value for significant difference in variance at the .05 level, the variances about the two means were interpreted to be sufficiently different, indicating a significant relationship between usage and training on the CASE product (not on the selected methodology). The F ratio was 0.5909 with a significance at 0.4490.

Table 9. ANOVA for Satisfaction with CASE and Training Provided in the Methodology.

	Question 11 n=15 Satisfaction Level	Question 17 n=15 Amount of Training Given In the Methodology
Mean	0.66667	0.73334
Standard Error	0.12599	0.11819

Standard Error of Treatment Means	0.12215	
	Difference	Sig .05
Satisfaction vs. Training on Methodology	0.06667	No

F test ratio = 0.1489362
Significance = 0.7025
Degrees of Freedom = 1

Table 10. ANOVA for Satisfaction with CASE and Training Provided in CASE.

	Question 11 n=14 Satisfaction	Question 16 n=14 Training Given In CASE
Mean	0.7143	0.5714
Standard Error	0.1253	0.1373
Standard Deviation	0.4688	0.5136

Standard Error of Treatment Means	0.13151	

	Difference	Sig .05
Satisfaction vs. Training on CASE	0.1429	No

F test ratio = 0.5909
Significance = 0.4490
Degrees of Freedom = 1

Table 11 reports the analysis relating to differences between the means concerning the usage responses (Question 11) and the satisfaction with the training (Question 22). The F value was above the critical value for significant difference in variance at the .05 level and the variances about the two means were interpreted to be sufficiently different, indicating a significant relationship between usage and training. The F ratio was 0.8696 and the level of significance at 0.3622 (See Table 11).

Conclusions

From the analyses of the variances produced for the three hypotheses, the following conclusions are drawn.

Regarding the first hypothesis, the respondents to this survey indicated a strong relationship between the *a priori* existence of design and development standards in the department and the acceptance and usage of the Computer-Aided Software Engineering product. From this analysis it appears that those organizations that are contemplating the purchase and installation of a CASE software product should first implement mandatory standardization within their information systems departments.

For the second hypothesis the respondents appeared to experience little or no increase in CASE acceptance and usage when the same methodological standards were used both

Table 11. ANOVA for Satisfaction with CASE and Satisfaction with Training.

	Question 11 n=11 Satisfaction	Question 22 n=11 Satisfaction with Training
Mean	0.8182	0.63636
Standard Deviation	0.4045	0.5045
Standard Error	0.1220	0.15212

Standard Error of Treatment Means	0.13787	
	Difference	Sig .05
Satisfaction vs. Training on CASE	0.1818	No

F test ratio = 0.8696
Significance = 0.3622
Degrees of Freedom = 1

before and after the implementation of the software tool. From this result it would appear that organizations need not assure that the same methodologies be provided on the CASE product as those that were used before the product was installed.

For those respondents who did not use the same methodology but did have adequate education on the new methodology as well as on the CASE tool, there seemed to be no greater acceptance and use of the tool than for those who did not have as thorough training on the methodology. From these results it appeared that information systems managers need not offer extensive training on the methodology; training on the CASE tool seemed adequate.

The three null hypotheses, their respective f ratios and the outcome of whether each hypothesis was accepted or rejected are summarized in Table 12.

Summary

This research study attempted to determine whether various factors had a significant effect on the satisfaction a systems designer within the research sample had with a Computer-Aided Systems Engineering tool. The initial proposal asked three questions. First, was there a significant relationship between the satisfaction a systems analyst felt towards a CASE tool and the requirement for standardization within the department prior to the installation of the product? Second, for organizations that had _a priori_ standardization, did the use of the same methodology before and after the installation of the product significantly affect the acceptance of that product? Third, for those organizations without _a priori_ standardization, did training on the methodology as well as the product significantly affect the acceptance to that product?

From the analyses of variance there appeared to be some significant relationship among the three elements in question 1; the CASE users who had _a priori_ standards accepted and used the product more than those who had no _a priori_ standards. The decision criteria called for a rejection of the null hypothesis since the F ratio was higher than the .05 level of significance.

The results of the other two questions, however, demonstrated no significant relationships. In each of the two cases, the null hypothesis was not rejected since the F ratios were lower than the .05 level of significance.

Table 12. Summation of Hypotheses and the Results.

Hypothesis	F ratio	Result
Hypothesis 1: There is no significant difference in the usage of CASE systems between those companies that enforced systems standards before the CASE tool was implemented and those companies that did not have previously enforced standards.	3.006	Reject
Hypothesis 2: For those companies with enforced standards prior to CASE, there is no significant difference in the usage of CASE systems between those companies that imposed a methodology standard different from the one imposed after CASE implementation versus those companies that imposed the same methodology both before and after CASE installation.	0.0608	Accept
Hypothesis 3: For those companies that have CASE systems but did not have enforced standards prior to CASE, there is no significant difference in the usage of CASE systems between those companies that provided training in the selected methodology and those companies that provided no methodology training.	0.1489	Accept

SUMMARY AND CONCLUSION

This chapter provides a summary, examines the limitations of the research and presents suggestions for future research.

Summary of Research Study

The purpose of this study was to investigate the relationship between enforced methodological standards and user acceptance of Computer-Aided Systems Engineering tools. Besides looking at the standardization issue, two other areas were analyzed: the importance of selecting CASE tools offering identical methodologies to those being utilized and of providing training in the methodologies as well as CASE techniques once the product has been installed.

In order to ascertain the analysts' acceptance of a CASE product, a survey instrument was developed and mailed to 151 information systems departments in Ohio, Maryland, Virginia, and North Carolina. Selected departments were thought to develop a minimum of two major systems during a twelve-month period. A cover letter, explaining the purpose of the research and requesting an analyst complete the survey accompanied each questionnaire. The instrument was divided into three primary categories: the first gathered general historical and demographic data, the second determined the level of standardization and familiarity with design and development methodology and the third concentrated on methodological training provided for those departments using CASE systems.

Seventy-eight responses were returned, with only 2 of these unusable. Of these, 39 respondents used some form of CASE technology for systems design and development.

The responses were first summarized and tallied. As expected, those departments using CASE tools had the greatest number of full-time personnel and developed a higher number of systems than non-CASE users. The CASE users were then evaluated through an analysis of variance and the resulting f ratios tested.

The tests of the hypotheses that involved the situational variables provided these results:

(1) There is a significant correlation between having enforced standards prior to the installation of the Computer-Aided Systems Engineering tools and the acceptance and usage of the tools. The results of this study uncovered a significant relationship between these two variables. As indicated by these results, information systems managers should have established mandatory systems design and

development standards before selecting and installing CASE systems.

(2) For the group of CASE users with a priori standards a second analysis was performed. This analysis revealed no significant relationship between selecting CASE tools with methodologies identical to those used by systems analysts prior to CASE implementation and the acceptance to the product itself. From this sample it appeared that management need not concern itself about selecting CASE tools that provide the same types of methodologies as analysts and designers had been using. Such an outcome indicates that the choice of a CASE product may be based on criteria other than retaining like methodologies.

(3) The group of CASE users without a priori standards were analyzed to determine whether training on the methodology could influence the acceptance of the product. The assumption was that training could overcome the resistance to the product. From the analysis, however, it appeared that providing training on methodology had no significant relationship to the acceptance to CASE. In this study training on the methodology did not offset the resistance to the product.

These results suggest that a priori standardization is an important issue when evaluating a Computer-Aided Systems Engineering product. However, concern over selecting identical methodologies as currently used or over training needs in these methodologies is not warranted as neither of these issues appear to affect the overall acceptance and use of the CASE product.

Limitations of the Research

When interpreting the results of any study or attempting to make generalizations, it is necessary to consider limitations and possible weaknesses imposed by the research method or the research methodology.

Research Design

This study employed an instrument which was sent to information systems departments within a relatively small geographical area. The organizations included in this study were not randomly chosen. Most were contacted through an employee affiliation with one of two professional organizations.

Although the research instrument requested that the questions be answered by a systems analyst or by someone currently involved in systems analysis and design, there was no certainty that this occurred. It was possible that the employee who responded to the questionnaire worked in a department not familiar with CASE products although other departments within the company used the product.

The study employed a mailed survey with a request for an immediate response. Since all of the data was obtained from each user at a single point in time, cause and effect relationships cannot be inferred from the results.

Measures of Variables

Any research is obviously limited by the choice of variables in the model and by the measures used for those variables. A seven-point Likert scale was provided to give the respondent a choice in his/her answers. These responses were then collapsed into Yes or No answers for use in the analysis of variance.

Finally, other variables that were not included in the model could be related to those that were and would thus offer alternative explanations to the relationships among the variables.

Data Analysis

An analysis was conducted on three sample groups: the CASE users with *a priori* standards, those with enforced standards, and those without such standards. In each case there were several questions that were left unanswered and had to be omitted from the analysis. The sample size for the CASE users with no *a priori* standards was relatively small compared to the other two test groups.

Besides the analysis of variance, additional descriptive statistical measurements were calculated for responses concerning the historical and demographic data. These calculations were performed against the full 76 respondents.

Suggestions for Future Research

Numerous studies have been conducted in an attempt to provide insight into methods and techniques that can improve the systems analysis and design functions. Computer-Aided Systems Engineering tools, being relatively new in the systems area, have just begun to be considered important.

Several research efforts have indicated that companies that did implement CASE products found their employees resistant to using the products. As yet, a minimum amount of research has been attempted to discover the cause-and-effect relationship between acceptance and other variables. This effort studied one issue--standardization. Other issues relevant to this topic but not examined include:

1. Does immediate availability to the CASE product influence the usage of the product? How near in proximity must the product be located to the user?
2. Does the full integration of all phases of the systems development life cycle affect

acceptance? Must all phases be integrated or only a selected few?

3. Does the CASE tool destroy the "art" of systems design?
4. Are the personality traits inherent in a "good" systems analyst the same for those using CASE products as for those without automated tools?

Additionally, no attempt was made in this research effort to determine whether the CASE tool did improve the efficiency or the effectiveness of the systems analyst. Because of the expense incurred when purchasing and implementing a CASE product, further study in the area is imperative for information systems managers to feel more confident when selecting and installing a Computer-Aided System Engineering package.

Conclusion

From the sample responses available in this research effort there appeared to be a significant relationship between enforcing a priori standards and the acceptance to CASE products. Such a realization provides management insight as to one factor affecting the use of the product by information systems analysts and designers.

Because of the costs incurred with the installation and use of the CASE product, the information systems manager must attempt to overcome as much resistance to product use as possible. With the realization that enforced methodological standards prior to CASE installation substantially reduces the developer's resistance to the product, management can establish such development standards before considering the selection and installation of a particular CASE product. Thus, this study has provided IS management some insight into improving the acceptance and ultimate use of Computer-Aided Systems Engineering tools.

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APPENDIX

Exhibit A

CASE QUESTIONNAIRE

1. How many full-time systems analysts, systems designers, project leaders and/or programmers work in the information systems/data processing department of your organization. (Circle appropriate response)

1	2	3	4	5	6	7
< 5	5-49	50-99	100-149	150-199	200-249	> 250

2. How many major systems--those requiring a minimum of two months development time--were produced within your department during the last 12 months? (Circle appropriate response)

1	2	3	4	5	6	7
< 2	2-4	5-9	10-14	15-19	20-24	> 25

3. What is your job title?

___ Director
___ Manager
___ Supervisor
___ Other (Specify) ______________________________
___ Systems/Computer Analyst
___ Analyst/Programmer
___ Programmer

4. How many years has this organization had an information systems/data processing department? (Circle appropriate response)

1	2	3	4	5	6	7
< 5	5-9	10-14	15-19	20-24	25-29	> 30

5. Does the company require the use of one or more standard methodologies--such as data flow diagrams, entity-relationship diagrams, DeMarco diagrams, Warriner/Orr diagrams, etc.--during systems development? (Circle appropriate response)

1 2 3 4 5 6 7
Never -- Always

6. How strictly are these standards enforced? (Circle appropriate response)

1 2 3 4 5 6 7
Never -- Always

7. Did the company require the use of one or more standard methodologies--such as data flow diagrams, entity-relationship

diagrams, DeMarco diagrams, etc.--prior to the installation of a CASE tool? (Circle appropriate response)

1 2 3 4 5 6 7
Never -- Always

8. How available is a Computer-Aided Software Engineering (CASE) tool to systems analysts, project leaders and/or programmers. (Circle appropriate response)

1 2 3 4 5 6 7
Never -- Always

IF the ANSWER to Question 8 is NEVER, please answer a, b and c below and STOP; otherwise, skip to Question 9 below.

a. Has your company had any CASE tools available for use anytime during the past two years?

______ Yes ______ No

b. Is your company, to your knowledge, currently considering the use of CASE systems?

______ Yes ______ No

c. Why do you feel CASE has not been installed or required by your company? (Check all appropriate responses).

______ Too expensive ______ Too difficult to use
______ No cost benefit ______ Increased time needed
______ Employees object ______ Too structured
______ Other (please specify) ________________________
____

9. How involved were your in the evaluation and selection of a CASE tool? (Circle appropriate answer)

1 2 3 4 5 6 7
None -- Total

10. Is use of the CASE tool mandatory in your installation?

1 2 3 4 5 6 7
Never -- Always

11. If the tool used is/were voluntary, how often would you use it to design and develop systems? (Circle appropriate answer)

1 2 3 4 5 6 7
Never -- Always

12. How familiar were you with the methodology supported by the CASE system selected by your department? (Circle appropriate response).

1	2	3	4	5	6	7
Not at all						Totally Familiar

13. Under what circumstances would you use the CASE tools more often? (Check all answers which apply)

______ Tools installed on the computer at my desk
______ More education on the supported methodology
______ More education on the CASE product
______ Easier manipulation of the components of the product
______ Less duplication of effort when going from one phase to another
______ Other (Please specify) ______________________________
____

14. Which of the following systems methodologies have you used at any time in on-the-job systems development:

___ E-R diagrams (Chen)
___ data flow diagrams (DFD)
___ DeMarco diagrams
___ structure charts
___ HIPO charts
___ Warriner/Orr diagrams
___ systems flowcharts
___ program flowcharts
___ other (Please specify) ______________________________
____

15. Did you use the same methodologies <u>before</u> and <u>after</u> the CASE product was selected? (Circle appropriate response)

1	2	3	4	5	6	7
Never						Always

16. How much training did you receive on the CASE product? (Circle most appropriate response)

1	2	3	4	5	6	7
None	1/2 day	1 day	2 days	3 days	4 days	> 4 days

17. How much training did you receive on the supported methodologies? (Circle appropriate response)

1	2	3	4	5	6	7
None	1/2 day	1 day	2 days	3 days	4 days	> 4 days

18. How satisfied are you with the CASE product you are using? (Circle appropriate response)

1 2 3 4 5 6 7
Dissatisfied ------------------------------------ Satisfied

19. How do you feel about using a standardized methodology when developing systems? (Circle appropriate response)

1 2 3 4 5 6 7
Dissatisfied ------------------------------------ Satisfied

20. How much input did you have in the evaluation and selection of the CASE product? (Circle appropriate response)

1 2 3 4 5 6 7
None -- Complete

21. How knowledgeable were you with the CASE-supported methodology prior to the installation of the product? (Circle appropriate response)

1 2 3 4 5 6 7
Not Knowledgeable --- Completely Knowledgeable

22. How satisfied were you with the training you received on the CASE product? (Circle appropriate response)

1 2 3 4 5 6 7
Not Satisfied --- Completely Satisfied

23 In your opinion, how strongly should the organization enforce standardized methodologies? (Circle appropriate response)

1 2 3 4 5 6 7
Never -- Totally

24. How helpful is the CASE product in the systems development process? (Circle appropriate response)

1 2 3 4 5 6 7
Not at all -- Extremely

Exhibit B.

To: Systems Analysts, Designers, Developers

From: Joyce M. Rowe

Date: June 5, 1990

Re: CASE Survey

As part of my dissertation research in pursuit of a doctoral degree in Information Systems from Virginia Commonwealth University, I am fielding the enclosed survey instrument. I am certain that your schedule is a busy one. However, this questionnaire is being sent to a small, selected sample of individuals in the systems analysis, systems design and systems development.

I would appreciate it very much, therefore, if you would take a few moments to complete the questionnaire and return it to me in the enclosed, self-addressed, stamped envelope. Your responses should represent your personal attitude concerning a product or an issue rather than the position of your organization, unless otherwise stated.

Thank you very much for your assistance. If you would like to receive the results of this study upon its completion, please complete the enclosed slip with your name and address and return it with the questionnaire.

Enclosures

EXHIBIT 1. Question 7. Did the company require the use of one or more standard methodologies...prior to the installation of a CASE tool?

FREQUENCY HISTOGRAM:

	Lower Limit	Frequency	Percent
ANOVA 0:			
	1	8	22
	1.66667	7	19
ANOVA 1:			
	3	2	5
	3.66667	4	11
	5	4	11
	5.66667	11	30
	7	1	3

===

EXHIBIT 2. Question 9. How involved were you in the evaluation and selection of a CASE tool?

FREQUENCY HISTOGRAM:

	Lower Limit	Frequency	Percent
ANOVA 0:			
	1	16	42
	1.66667	5	13
ANOVA 1:			
	3	1	3
	3.66667	3	8
	5	3	8
	5.66667	4	11
	7	6	16

EXHIBIT 3. Question 11. If the tool used is/were voluntary, how often would you use it to design and develop systems?

FREQUENCY HISTOGRAM:

	Lower Limit	Frequency	Percent
ANOVA 0:			
	1	1	3
	1.66667	6	16
	3	4	11
ANOVA 1:			
	3.66667	7	13
	5	4	11
	5.66667	8	21
	7	10	26

===

EXHIBIT 4. Question 15. Did you use the same methodologies before and after the CASE product was selected?

FREQUENCY HISTOGRAM:

	Lower Limit	Frequency	Percent
ANOVA 0:			
	1	6	16
	1.66667	3	8
	3	3	8
ANOVA 1:			
	3.66667	6	16
	5	7	18
	5.66667	9	24
	7	4	11

EXHIBIT 5. Question 17. How much training did you receive on the supported methodologies?

FREQUENCY HISTOGRAM:

	Lower Limit	Frequency	Percent
ANOVA 0:			
	1	7	20
	1.66667	2	5
ANOVA 1:			
	3	5	14
	3.66667	2	5
	5	3	8
	5.66667	1	3
	7	17	46

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EXHIBIT 6. Question 16. How much training did you receive on the CASE product?

FREQUENCY HISTOGRAM:

	Lower Limit	Frequency	Percent
ANOVA 0:			
	1	7	20
	1.66667	7	20
ANOVA 1:			
	3	2	6
	3.66667	3	9
	5	7	20
	7	9	26

EXHIBIT 7. Question 22. How satisfied were you with the training you received on the CASE product?

FREQUENCY HISTOGRAM:

	Lower Limit	Frequency	Percent
ANOVA 0:			
	1	3	18
	1.66667	1	6
ANOVA 1:			
	3.66667	3	18
	5	2	13
	5.66667	3	18
	7	4	27

Vita

Joyce M. Rowe was born on July 24, 1945, in Richmond, Virginia and is an American citizen. She graduated from Highland Springs High School, Henrico County, Virginia, in 1963. She received her Bachelor of Science in Education from Virginia Commonwealth University in 1967 and subsequently taught in the Richmond Public Schools for two years. She received a Master of Science in Business with a concentration in Information Systems from Virginia Commonwealth University in 1970. She taught as an instructor at Virginia Commonwealth University from 1970 through 1982, at which time she became a Data Base Administrator for Philip Morris, Incorporated. She remained in the information systems department in that company until 1987, when she joined the faculty at Virginia State University as an Assistant Professor.