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PROGRAM DEVELOPMENT FOR CAD/CAM TECHNICIANS
BASED ON AN OCCUPATIONAL ANALYSIS

By

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ABSTRACT

PROGRAM DEVELOPMENT FOR CAD/CAM TECHNICIANS BASED ON AN OCCUPATIONAL ANALYSIS

By

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There is a need to train people to operate computer-aided design/computer-aided manufacturing (CAD/CAM) systems in southern Michigan. This study addressed the establishment of programs to train CAD/CAM technicians, the people who operate CAD computer terminals that transmit data to a CAM data base or machine tool in a manufacturing setting. With the changing manufacturing methods in design drafting and machine tooling, it is critical to identify the duties and tasks necessary to perform the job of a CAD/CAM technician.

Therefore, the specific problem focused on in this study was the identification of competencies necessary to perform the job of CAD/CAM technician. The major objectives of the study were:

1. To provide a functional definition of the emerging occupation of CAD/CAM technician.

2. To identify the duties and tasks performed by CAD/CAM technicians. Emphasis was given to the CAD/CAM hardware and

software, but attention was also given to industrial applications of the CAD/CAM system.

3. To identify the frequency with which each task is performed and to determine the relative importance of each task for job entry.

4. To identify program-development models for using the products of an occupational analysis in developing programs to train CAD/CAM technicians.

5. To provide guidelines for using the products of this occupational analysis in developing programs to train CAD/CAM technicians.

The data collected to meet the first four objectives were obtained by reviewing the literature and interviewing incumbent CAD/CAM technicians.

The results of Objectives 1, 2, and 3 included a functional definition of a CAD/CAM technician and a validated list of 9 duty and 105 task statements. Tables showing the frequency with which tasks were performed and the importance of the tasks to job entry were included. Nineteen tasks were found to be essential for job entry, and 60 tasks were found to be performed daily.

The fourth objective was met by reviewing five instructional-development models that use occupational/task-analysis data. The fifth objective was met by designing a program-development model to apply the product of this occupational analysis.

In memory of my sister, Judy Ann (Boyer) Rabe.

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CHAPTER I

INTRODUCTION TO THE STUDY

Background

The concepts of computer-aided design (CAD) and computer-aided manufacturing (CAM), which have been evolving for more than 25 years, will continue to expand with respect to application, development, and implementation (Kief, 1985). With the advent of low-cost computer capabilities, CAD has emerged as a flexible method for designing parts and equipment. CAM has emerged from computer-aided parts programming. Today, CAD includes all of the aspects involved in computer-aided production of engineering data such as drawings, geometric models, finite-element analysis, parts lists, work schedules, and numerical control (NC) information. CAM encompasses all of the applications of computers to a wide variety of manufacturing functions, such as process planning, production scheduling, NC, computer numerical control (CNC), quality control, and assembly.

Over the years, the terms "CAD" and "CAM" have become combined into CAD/CAM. CAD/CAM represents the integrated approach to the use of computers in the total production process, encompassing both the design and manufacturing phases. The goal of integrating CAD and CAM is to systemize the flow of information from the preliminary design phase of a product through the completion of its production (Kief, 1985).

Traditionally, a design involves transforming a concept into design information that is communicated to others through a drawing and related documents. However, this method is cumbersome and expensive and requires a large number of designers. Also, there is no convenient way to interact with the design information and the production information needed in manufacturing. CAD/CAM provides an opportunity to improve productivity in the work place by providing a linkage between design and manufacturing.

With the increasing sophistication of CAD/CAM systems, it now is possible to use the geometric model created on a CAD system as a basis for producing NC instructions, so the user need not manually enter geometric data into a machine tool. Furthermore, machining information is provided through interactive question-and-answer prompts on the terminal. As a result, these systems allow NC instruction to be created graphically without requiring knowledge of programming languages.

John Krouse (1986b), editor of Computer Aided Engineering magazine, stated:

> Computer-aided design and manufacturing (CAD/CAM) systems enable engineers to rapidly design mechanical parts, analyze them to close tolerances and directly generate machining instructions. By thus avoiding time-consuming and expensive manual drawing and prototype work on the shop floor, companies can significantly reduce the time and cost of developing new products. As this advantage takes CAD/CAM into more and more industries, revenues from CAD/CAM should rise from an estimated $3.5 billion in 1985 to $12.7 billion by 1990.
>
> Until recently, the CAD/CAM industry predominantly marketed stand-alone machines. Now, however, most vendors offer systems

> in which four or five work stations work under the direction of a central 32-bit minicomputer. IBM leads the industry with 21.4% of the market. The rest of the market is largely divided among Intergraph with 15%, Computervision with 12%, GE Calma with 6%, and other suppliers.
>
> The industry is currently in transition from the 1980-85 period, when annual compound growth rate was nearly 37%, to an era of lower, but still rapid, expansion. Revenues are expected to increase by 29% per year over the remainder of the decade, particularly those involving solid modeling software and systems based on personal computers.
>
> Solid modeling software generates a data-base that can be effectively shared to support a variety of functions; including structural analysis, mechanical simulation, and numerical control programming needed throughout the CAD/CAM process. (p. 42)

In a study entitled "Computer Aided Design" conducted for the Michigan Department of Education in 1982, 78 companies indicated they were using CAD systems; 148 businesses were planning to use CAD in the future. In the 78 companies using CAD systems, 1,138 people reported working on those systems (Boyer, 1982).

CAD/CAM will surely change the duties and tasks of draftspersons. A typical mechanical drafter or engineer drafter today drafts detailed working drawings of machinery and mechanical devices, indicating dimensions and tolerances, fasteners and joining requirements, and other engineering data (Dictionary of Occupational Titles, 1977). A draftsperson also drafts multiple-view assembly and subassembly drawings as required for manufacturing and repair of mechanisms (Dictionary of Occupational Titles, 1977). CAD systems will allow a draftsperson to work beyond this limited job description of because of the CAD's capabilities and the speed at which it produces finished prints.

Christenson, Johnson, and Stinson (1982) wrote in their book on supervision:

> A major development of the sixties was the evolution of micro-electronics. The semi-conductor and electronic chip paved the way for electronic controls in all areas of the economy. In the office this has resulted in computer-controlled accounting processes. In the plant it has led to computer-aided design and computer-aided manufacturing (CAD/CAM) techniques, and even to a major new form of mechanization--robotics. These developments in turn have created an entirely new environment to which supervisors and workers alike must adapt or face obsolescence. (p. 21)

They also noted:

> Neither the worker nor the supervisor will go untouched in the next decade. It fact, the success of an organization in the future will largely depend on how effectively they utilize the new technology. Directing workers in this area is perhaps one of the most challenging tasks supervisors will face. (p. 21)

Need for the Study

The single most dominant element in technology education in the 1980s and beyond is the integration of computers into traditional instructional programs. This is in response to the reliance of virtually every branch of industry on computer technology. Literally every job function in industry that technology graduates fill will become "computer-aided something" during their working careers (South, 1984).

Recent projections have indicated that, in the drafting area alone, 10,000 CAD-based design/drafters will be needed nationally in the next four years. Some of the new CAD operators will be trained by their employers. However, the majority will be trained at community and technical colleges that offer associate degrees and/or certificate programs in drafting (South, 1984).

The advent of CAD/CAM has created a need to upgrade the skills of people in the fields of mechanical drafting and machine tooling, so they will be able to use CAD/CAM systems. There also is a need to produce new graduates who can enter the CAD/CAM field at a competent level. Educators need to customize their curricula to meet the training needs of this field.

The CAD/CAM curriculum must be built on an occupational analysis that identifies the duties and tasks performed on the job. Once specific worker skills are identified, the types of educational experiences a potential worker should be provided in order to be competent in those skills can be developed (Center for Vocational Education, 1978).

Statement of the Problem

The problem addressed in this study was the need to establish programs to train CAD/CAM technicians, the persons who operate CAD computer terminals that transmit data to a CAM data base or machine tool in a manufacturing setting. With the changing manufacturing methods included in design drafting and machine tooling, it is critical to identify the duties and tasks necessary to perform the job of a CAD/CAM technician. The changing occupational requirements necessary for these technicians were mentioned in the introduction. Yet the necessary training in a high-technology field, as in any other, cannot be accomplished before the work done by incumbent workers has been analyzed.

Therefore, the specific problem on which this researcher focused was the identification of competencies necessary to perform the job of CAD/CAM technician. The product of this analysis is a validated duty and task listing, along with a program-development model for training CAD/CAM technicians. This model includes guidelines for using the duties and tasks validated in the present research.

Objectives of the Study

The following objectives were the main focus of this study:

1. To provide a functional definition of the emerging occupation of CAD/CAM technician.

2. To identify and list the duties and tasks performed by CAD/CAM technicians. Emphasis was given to the CAD/CAM hardware and software, but attention also was given to industrial applications of the CAD/CAM system.

3. To identify the frequency with which each task is performed and to determine the relative importance of each task for job entry.

4. To identify program-development models for using the products of an occupational analysis.

5. To provide a program-development model and guidelines for using the products of this occupational analysis to develop programs to train CAD/CAM technicians.

The first four objectives were addressed by means of four research questions. The fifth objective was addressed through a review of the literature, which is contained in Chapter II.

Research Questions

The following research questions were posed to guide the collection of data to address the first four objectives of the study.

1. What is a functional definition of the occupation of CAD/CAM technician?

2. With emphasis given to the CAD/CAM hardware and software and attention to the industrial applications of the systems, what are the duties and tasks performed by CAD/CAM technicians operating these systems?

3. What tasks are most frequently performed by a CAD/CAM technician, and which tasks are the most important for a technician to be able to perform at job entry?

4. What program-development models can be identified for using the products of this occupational analysis?

Research Methodology and Data-Analysis Procedures

The first research question was answered by means of a jury technique, using the following steps:

1. Reviewing related job descriptions, including CAD/CAM technicians, computer draftsmen, graphic technicians, and other related occupations.

2. Reviewing the literature concerning the job duties of CAD/CAM technicians.

3. Developing a preliminary job description.

4. Pilot testing the job description with two college faculty members in the field of CAD and CAM.

5. Developing a questionnaire for CAD/CAM technicians and/or supervisors to rate the preliminary job description.

6. Mailing the questionnaire to a jury of seven CAD/CAM technicians.

7. Analyzing questionnaires completed by the jury of technicians and developing a revised job description.

8. Distributing the revised job description to the same jury. Asking the jury to review and rate the job description on a five-point scale from "acceptable" to "unacceptable" after additional revisions have been made.

9. Repeating Step 8 if necessary.

10. Writing the final job description.

To answer the second research question, the occupational analysis technique was used. The following steps were implemented:

1. Reviewing operating manuals of CAD/CAM systems to develop appropriate duty and task listings.

2. Reviewing duty and task statements from existing occupational analyses.

3. Reviewing textbooks in the field of CAD/CAM to develop duty and task statements.

4. Developing duty statements from the researched materials.

5. Preparing task statements for each duty statement.

6. Organizing the duty and task statements into a preliminary inventory.

7. Conducting personal interviews (pilot testing the inventory) with selected CAD and CAM educators, incumbent workers, and CAD/CAM operators and supervisors.

8. Revising the inventory based on information received during the interviews.

9. Developing an interview schedule to include the duty and task statements with provisions for rating "frequency performed" and "importance for job entry."

10. Selecting a sample of CAD/CAM technicians and supervisors from a target population consisting of technicians who operate common CAD/CAM systems for a variety of industrial applications and have had six months or more experience in the field.

11. Verifying the duty and task inventory by interviewing volunteer incumbent CAD/CAM technicians and supervisors with six months or more experience.

12. Categorizing and displaying the data in tables.

The third research question was answered by arranging and displaying the data in tabular form. These tables show the frequency with which the tasks are performed, respondents' ratings of the importance of each task, correlations between the frequency with which each task is performed and the importance of each task for job entry, a ranking of the tasks in terms of importance, and a list of tasks that received an importance score of 3.5 to 4.0 (essential).

The researcher addressed the fourth research question by (a) reviewing the literature and other sources to identify strategies for using occupational-analysis data to develop an occupational or technical education program and (b) synthesizing the findings for application to this study.

The focus of the program-development models identified in this study was the program level, as described in the Definition of Terms. The scope of these models is broader than a single course but narrower than a total curriculum.

Assumptions

In conducting this study, the writer made two assumptions:

1. The CAD/CAM technicians who were interviewed had sufficient experience to respond to the questionnaire.

2. The CAD/CAM technicians who were interviewed represented the population of CAD/CAM technicians at this time because CAD/CAM technician is a new and growing occupation.

Delimitations of the Study

The study was delimited in the following ways:

1. Only CAD/CAM technicians and supervisors with six months or more experience and employed in southern Michigan were included in the sample.

2. Not all types of CAD/CAM systems or all possible industrial applications were represented in the study.

3. The program-development model and guidelines developed in response to Objective 5 were not designed for use in general program development.

Definitions of Terms

The following terms are defined in the context in which they are used in this dissertation.

CAD/CAM technician: A person who operates a CAD computer terminal that transmits data to a CAM data base (a machine tool) in a manufacturing setting.

Computer-aided design (CAD): Designing with graphics using the capabilities of a computer to create, transform, and display pictorial and symbolic data.

Computer-aided design/computer-aided manufacturing (CAD/CAM): Using the computer to integrate design and manufacturing.

Computer-aided manufacturing (CAM): Using a computer to assist in the manufacturing process.

Computer graphics: A process in which computers are used to create graphics, which includes management information, scientific graphics, command and control, image processing, and real-time image.

Computer-integrated manufacturing (CIM): Integrating a total manufacturing facility by means of a common data base. CIM facilitates the "automated factory."

Computer numerical control (CNC): Using a dedicated computer within a numerical control unit that provides data input for the NC machine.

Course: A discrete segment of a program, which covers specific, measurable behavioral objectives of knowledge, attitudes, or practices related to a given discipline or occupation (Wenrich & Wenrich, 1974).

Curriculum: The entire spectrum of educational experiences made available to students through a given institution. The curriculum comprises many programs, and each program consists of an aggregate of courses (Wenrich & Wenrich, 1974).

Duty: A large segment of work performed by an individual. It is one of the distinct major activities involved in the work performed and is composed of several related tasks (Melching & Borcher, 1973).

Numerical control (NC): A means of providing prerecorded information that gives complete instructions for the operator of a machine.

Occupational analysis: A process through which an occupation is analyzed and the skills and knowledge necessary for successfully fulfilling the requirements of that occupation are documented (Steely, 1981).

Program: The aggregate educational offerings of a school or college related to a specific occupation or occupational cluster. A program covers all the knowledge, values, attitudes, and manipulative skills associated with job entry in a given occupational area (Wenrich & Wenrich, 1974).

Task: A job activity or set of activities that, if begun by one individual, is generally completed by that person. It is usually not practical to subdivide the task so that more than one worker can specialize in doing various parts of it (Rupe, 1975).

Task analysis: A systematic examination of a task and the identification of the steps, operations, or elements involved in that task (Center for Vocational Education, 1978).

Overview of the Dissertation

A review of the literature pertaining to the study is presented in Chapter II. The literature review is focused on four topics: purposes of and methods used in analyzing occupations, five strategies or models for using occupational-analysis data to develop vocational or technical education programs, a comparison of the five models for use as a program-development model, and existing duty and task statements for CAD/CAM technician.

The study design is the focus of Chapter III. The chapter is organized around the methods used to answer the four research questions. Included are the development of a functional definition of the occupation of CAD/CAM technician and the four major components of the analysis: development of the duty and task inventory, selection of participants, collection of the information, and analysis of the data.

The data and findings related to the research questions are presented in Chapter IV. Chapter V contains a summary of the study, conclusions regarding the five objectives and four research questions, recommendations, implications for further research, and reflections.

CHAPTER II

REVIEW OF THE LITERATURE

The review of the literature pertaining to this study is focused on four topics: (a) purposes of and methods used in analyzing occupations, (b) five strategies or models for using occupational-analysis data to develop vocational or technical education programs, (c) a comparison of the five models for use as a program-development model, and (d) existing duty and task statements for CAD/CAM technicians.

Analyzing Occupations

Purposes of Analyzing an Occupation

An occupational analysis defines a worker's role--that is, what the worker does on the job. According to the Center for Vocational Education (1978a), the information gathered from an occupational analysis can be used for four purposes:

1. The information is often given to a prospective worker to explain what he/she is or will be expected to do on the job.

2. An analysis can serve as a basis for organizing the job.

3. Educational programs can be developed using the analysis. Once specific worker skills are identified, a sound basis exists for identifying the types of educational experiences a potential worker should be provided in order to be competent in those skills.

4. An analysis of a job can serve as an evaluation tool. Knowing what is involved in a job enables one to determine whether an individual is carrying out his/her work role.

> For vocational teachers, the overriding purpose of conducting an analysis of an occupation is to obtain a sound basis for designing, revising, or updating a training program. It also helps teachers evaluate the progress of students toward their occupational goals. By using the information secured through an analysis, teachers have a basis for decision-making. (p. 6)

As a bridge between people and their work, vocational and technical programs must be carefully planned. Once an educational agency decides to offer a program aimed at preparing workers for a particular occupation, the next step is to determine the actual work performed in that occupation and the duties and tasks required of workers. Wenrich and Wenrich (1974) wrote,

> Occupational analysis determines what the worker needs to know and be able to do in order to function effectively in a particular occupation. It is the basis for determining content for specialized vocational and technical education programs because along with each skilled, technical, paraprofessional or professional occupation there is a substantial set of relatively stable behaviors which can be described and taught. (p. 162)

In his book on job analysis, Fryklund (1970) wrote, "In order to teach an occupation or a subject or an activity there must first be an inventory of the elements to be taught" (p. 1). He also noted that

> The occupational analysis technique is necessary in the training of industrial and technical training personnel. The occupational elements become habits, and habits are not noticeable to those who have them; therefore it is necessary to analyze the occupation and list the elements so the new instructor will know what to teach. Experienced teachers also gain much from reanalyzing their work from time to time to keep it up-to-date. (p. 13)
>
> . . . .
>
> It is important to know that any given kind of work that is worthy and is complicated enough to make instruction necessary

> should be analyzed into its elements before attempting to teach it, if thorough instruction is desired. (p. 51)

In their book Developing Vocational Instruction, Mager and Beach (1967) underscored the importance of job/task analysis:

> Regardless of subject matter, the object of vocational instruction is to send the student away (1) capable of performing satisfactorily on the job and (2) capable of improving his skill through further practice.
>
> To achieve the first goal, it is necessary to know what the job consists of, what one needs to perform each of the tasks, and how frequently each task is performed. The student must be provided with practice in performing these tasks under conditions as much like the job as possible. To reach the second objective (improving skill through performance), it is essential that the student be taught enough about each task so that he can tell the difference between doing it right and doing it wrong (discriminate between perfect performance and imperfect performance), so that he can evaluate his own attempts to perform each job task. (p. 21)

Methods Used in Analyzing Occupations

Five basic approaches are used in analyzing occupations: the Developing A CurriculUM (DACUM) approach, the function approach, the occupational/task analysis, the critical-incident technique, and the Delphi technique (Finch & Crunkilton, 1978).

DACUM. DACUM was created as a joint effort of the Experimental Projects Branch of the Canadian Department of Manpower and Immigration and General Learning Corporation of New York. Adams (1975) defined DACUM as a "single sheet skill profile that serves as both a curriculum plan and an evaluation instrument for occupational training programs" (p. 24).

Buchar (1982) explained the DACUM process as follows:

> 1. It is used in identifying tasks as a basis for program planning. Since the DACUM originated, it has proven to be a very effective method for quickly deriving, at a relatively

low cost, the competencies or tasks that must be performed by persons employed in a given position or occupational area. It's used to determine the "what" of a curriculum, the content that needs to be known.

2. The DACUM process utilizes small group brainstorming techniques in order to arrive at what is basically a skill profile for a particular job.

3. A carefully chosen group of about 10-12 experts in the occupational area to be studied form the DACUM committee. Committee members are recruited directly from business, industry, or the professions.

4. The committee first identifies the general areas of competence in an occupation or job.

5. After the general competency areas are identified skill statements are then listed for each general area.

6. After the DACUM process has been completed the committee may sequence the activities (skills) to better refine the individual skills. This is also done because one task or skill must sometimes be mastered before another. (n.p.)

DACUM provides a fast method of developing a list of tasks or skills needed to perform a job. The skill profile sheets developed through this method can be used for instructional purposes, in developing a course or program. The weaknesses of this method are that it offers only limited input by professionals in the field and that is does not provide a process through which to analyze the skills or tasks in terms of importance to job entry or frequency with which they are performed.

Function approach. The function approach is primarily concerned with identifying content in terms of unifying characteristics across a particular industry or business. This strategy focuses on the functions of a business or industry and was defined by Clark and Meaders (1968) as "the operations that must be performed in the total business or industry in order for it to be successful or to continue in operation" (p. 1). Clark and Meaders also stated that, in the function approach,

> The focus is on preparation for a particular "world of work" based on the identification of (a) the specific requirements for performance by individuals in terms of activities contributing to a particular function in a relationship to the unity of the overall industry and (b) the general requirements for living related to the specific relationships of the industry to the unity of society. . . . In other words, the functions and activities of an industry become the focal point from which curricular inputs are identified in planning vocational-technical education programs to meet the needs of students for successful employment in the industry. (p. 5)

Clark (1965) listed seven steps comprising the function approach:

1. Identify the functions performed in the entire industry.
2. Validate the functions by means of a jury of individuals from industry.
3. List competencies required for performance of the functions.
4. Secure validation of these competencies by personal interviews with a jury of people in the industry.
5. After validation of these competencies, make a detailed analysis of each competency item which was rated as important or essential by the jury of industry people. The detailed analysis is to be made in terms of understandings, skills, and abilities required for satisfactory performance in the industry.
6. Submit this analysis to a group of educators for validation.
7. Group the understandings, skills, and abilities into a suitable instructional unit.

The function approach is a good method to use in analyzing an occupation for the purpose of program or curriculum development and includes a good cross-section of industrial representatives. Industry people validate and rate competencies or tasks in terms of importance. A weakness of this approach is that it is too broad to define one job title and is very time consuming.

Occupational analysis. Occupational analysis is a process through which an occupation is examined and the skills and knowledge necessary for successfully fulfilling the requirements of that occupation are documented (Steely, 1981).

Steely (1981) outlined five steps in describing an occupation using an occupational analysis:

> Identify Job Title
>
> Define Job Description
>
> Outline Job Duties (major subdivisions of work)
>
> Outline Job Tasks (a series of activities with a common purpose that occur in close sequence. Tasks are sometimes referred to as competencies.)
>
> List Task Activities (short, simple operations that are frequently common to many tasks). They may also be described as procedural work steps or actions. (pp. 12-13)

Steely also stated: "Tasks are the key building blocks that make up an occupation. In the occupational analysis, each task performed by workers in a given occupation should be a logically differentiated segment of work activity" (p. 14).

Occupational-analysis data are collected using several techniques, including observation of workers, task surveys given to incumbent workers, workshop activities with incumbent workers to develop or react to previously developed task listings, and interviews with incumbent workers to identify duties and tasks (Steely, 1981).

Various definitions of occupational and task analysis have been offered. Minty (1984) wrote,

> Analyzing work in terms of what people do and can do on the job has been called occupational analysis, job analysis, task analysis, trade analysis, and position analysis. Some writers see little or no difference in many of these terms, others see differences which have major implications for how the analysis should be conducted. (p. 19)

The Center for Vocational Education (1978a) at The Ohio State University defined occupational/job analysis as

> the systematic identification, usually for instructional purposes, of the essential tasks which workers are required to perform on the job. Such an analysis may also include working conditions, technical knowledge required, and worker qualifications. (p. 7)

The Center defined task analysis as "the systematic examination of a task and the identification of the steps, operations, or elements involved in the task" (p. 7).

The occupational analysis method developed by the Center for Vocational Education (1978a) uses an interview technique as a check sheet to verify the duties and tasks of incumbent workers. The check sheet is used to identify the frequency with which each task is performed and the importance of each task to job entry and advancement.

The Center listed four basic steps in analyzing an occupation:

1. Define scope--develop a job description.

2. Prepare initial listing of duties and tasks, review literature, interview incumbent workers, pilot test, edit.

3. Verify the initial listing, identify sample population (random or stratified), interview incumbent workers to verify frequency of performance and importance of the task to job entry.

4. Compile final listing--analyze and report task inventory data. (p. 7)

Finch and Crunkilton (1979) defined task analysis as a "process wherein tasks performed by workers employed in a particular job are identified and verified. . . . The worker's job consists of duties and tasks he or she actually performs" (p. 121). Finch and Crunkilton noted that "while there are several possible ways that a task analysis may be conducted, the key to the success of this system is that it is both thorough and systematic" (p. 122). They listed five steps in conducting a task analysis:

1. Review relevant literature.
2. Develop an occupational inventory.
3. Select a worker sample.
4. Administer an inventory.
5. Analyze collected information.

These steps are also followed by the Vocational-Technical Education Consortium of States (V-TECS) in conducting their task analysis. V-TECS has shown this approach to be applicable to public vocational and technical education (Lee, 1976). V-TECS (1976) defined task analysis as

> A process of reviewing actual job content and context in business and industry for application to the development of performance objectives, criterion-referenced measures, and quality control within a program of vocational-technical education. (p. 3)

The United States Department of Labor and Manpower Administration (1972) developed an elaborate system for analyzing jobs. This system is outlined in the <u>Handbook for Analyzing Jobs</u> and is termed a "job analysis." Listed in the Handbook are four steps to follow in conducting a job analysis:

1. Review the literature to become familiar with the technolo gies of the jobs and characteristics of the industry to be studied.

2. Review job descriptions.

3. Observe and interview incumbent workers and complete a job analysis schedule or form (this form includes information on worker functions, work fields, machines, tools and equipment, materials and products, and worker traits).

4. Analyze the data.

This method of job analysis is extremely thorough. It provides information on worker functions and traits, general education and vocational preparation requirements, work experience and orientation requirements, licensing requirements, relation to other jobs and workers, machines, tools and equipment, materials and products, and a description of tasks.

The job analysis system developed by the United States Department of Labor and Manpower Administration outlined an elaborate procedure for analyzing the data collected. The data can be used for instructional purposes in course, program, or curriculum development. A weakness of this method is that it is extremely time consuming, and a team of highly trained people is needed to perform such a job analysis.

As discussed above, occupational analysis, task analysis, and job analysis are all used to validate job tasks for instructional purposes. The scope and method of the analysis process may vary, depending on how one defines these terms. Occupational analysis, task analysis, and job analysis are all thorough and systematic. These methods involve a good cross-section of industry people from whom to gather information, and they provide an excellent process for analyzing a job or occupation. A weakness of these methods is that they are time consuming.

Critical-incident technique. The critical-incident technique involves "procedures for collecting direct observations of human behavior in such a way as to facilitate their potential usefulness in solving practical problems" (Flanagan, 1954, p. 327). Using this technique, a supervisor would write a series of anecdotes or stories outlining a worker's day-to-day activities. The supervisor would complete a form for each critical incident that he/she could remember (Finch & Crunkilton, 1979). Finch and Crunkilton (1979) noted:

> A major contribution that the critical incident technique can make to curriculum content identification is its potential to deal more directly with isolating important values and attitudes.
>
> While task analysis and similar approaches are useful in the identification of content, they tend to focus more exclusively on technical content and less directly on affective concerns. (p. 129)

The critical-incident method can be used to supplement a curriculum- or program-development model. The data collected can be used in developing program goals and course objectives dealing with affective topics. A weakness of this approach is that it cannot be used to develop a total instructional program.

The Delphi technique. The Rand Corporation developed the Delphi technique for predicting alternate defense futures, and it has seen widespread use in many areas of education (Weaver, 1971). Finch and Crunkilton (1979) elaborated on the uses of this technique:

> The Delphi technique has been found to be a useful tool for setting priorities, establishing goals, and forecasting the future. This technique is useful in curriculum development by providing a means of insuring that most relevant content is included and least relevant is excluded. This technique is also good for gathering information on new and emerging occupations where no workers exist at the present time. (p. 132)

The Delphi technique consists of a series of interrogations of individuals (experts) by means of mailed questionnaires. The focus is on a content area about which each individual is knowledgeable. Several rounds of questionnaire mailings are usually used in conducting a Delphi study. Borg and Gall (1983) described the procedures involved in this technique:

> The first step in a typical Delphi study is to prepare a set of questions or statements for evaluation. For example, in a study of educational goals, the initial questionnaire may list the school's current goals, ask a sample of community leaders to indicate the importance of each goal on a 5-point scale, and add any goals not included in the questionnaire. An open-ended approach can also be used in the initial questionnaire in which each respondent would be asked to list goals that he or she considers important.
>
> Based on the responses to the initial questionnaire, a revised questionnaire is then circulated. If ratings or rankings were obtained on the initial questionnaire, the median score for each item is given in the second questionnaire. This questionnaire is then returned to the same respondents, who are asked to compare their original ratings with the median score and to revise their original evaluations as they see fit. This procedure is repeated for at least four rounds in an effort to obtain a well-thought-out consensus.
>
> In effect, the Delphi technique uses mailed questionnaires to engage the respondents in an anonymous debate in order to arrive at consensus on issues or on predictions of future events. (pp. 413-14)

The Delphi technique can be used for identifying duties and tasks for new and emerging occupations for which there are limited informational resources. A major problem with using this technique is getting a group of dedicated people in the field to respond to each round of questionnaires. Although the Delphi technique can provide much meaningful information, "the entire process consumes a considerable amount of time and relies on participants who have stamina. [Yet] even with its disadvantages the Delphi technique may be the only route to take for certain curricular areas" (Finch & Crunkilton, 1979, p. 32).

Five Strategies or Models for Using Occupational/Task-Analysis Data to Develop Vocational- or Technical-Education Programs

Five strategies or models that can be used for developing vocational- or technical-education instructional programs are discussed in this section. All five models use occupational/task-analysis data for instructional purposes. The models were developed by (a) Harold Resnick, Director of Planning and Evaluation, Minuteman Regional Technical School District, Lexington, Massachusetts; (b) Philip R. Teske; (c) Robert Steely, Michigan Department of Education; (d) The Center for Vocational Education at The Ohio State University; and (e) Robert F. Mager and Ken Beach, Jr.

The Resnick Curriculum Model

The Resnick curriculum model (Figure 2.1) is a systems approach to curriculum development (Silvius & Bohn, 1961). Resnick's model starts with the development of a population profile and the determination of general curriculum goals. The next step in his systems approach is to establish the overall and major behavioral objectives

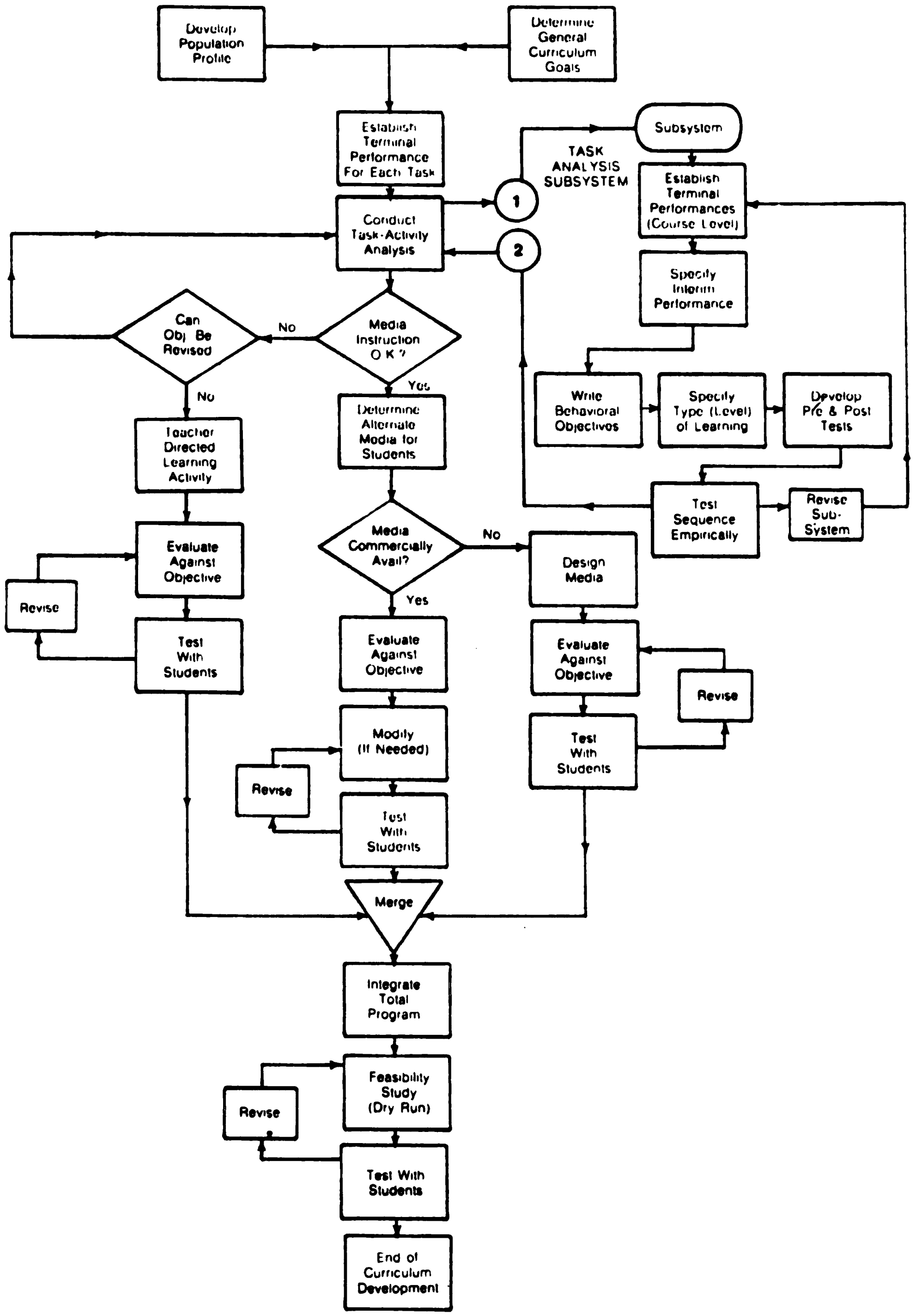

Figure 2.1: The Resnick curriculum model. From G. H. Silvius and R. C. Bohn, Planning and Organizing Instruction (Bloomington, Ill.: McKnight Publishing Co., 1961), p. 88.

for each course of study. The next step is a task-activity analysis to identify content and activity that would provide the vehicle for the needed educational experience. This step is essential for moving the student from the competence that he/she brought to the course to that specified in the terminal performance objectives (or outcomes). Resnick provided for a task-analysis subsystem wherein a subperformance objective, with its content identified, can be instituted for each major task within the hierarchy of the course or courses in a curriculum (Silvius & Bohn, 1961).

At this point in Resnick's plan, a decision needs to be made for each behavioral objective and the task identified for its fulfillment. The instructional strategy must be determined.

Resnick's model provides for refining and improving the effectiveness of each instructional package by (a) evaluating content and activities against the objective, (b) testing the students, and (c) revising where desirable. Finally, all of the packages are merged as one course or a major curriculum. The final product is then field tested with a trial run and further refined as the teacher continues to use the system with subsequent students (Silvius & Bohn, 1961).

Resnick stated, "This model is not the model for all situations but merely an illustration that depicts one method of organizing a curriculum emphasizing a systems approach" (silvius & Bohn, 1961, p. 86). Users should carefully examine Resnick's model and alter it to suit their needs. The model provides a good evaluation scheme during program development, but a continual evaluation system should also be included to keep the program current and to provide for instructional improvement. Resnick's use of the term "task analysis" is vague, and his procedure for conducting a task analysis is not identified. The model needs a step or steps at the beginning of the process to deal with the identification, clustering, and sequencing of tasks.

The Teske Curriculum Model

The Teske curriculum model is shown in Figure 2.2. Concerning curriculum development, Calhoun and Finch (1982) stated that:

> Tentative aims should be determine early in the process of curriculum development because they (a) locate the ends toward which effort should be directed; (b) act as guiding principles throughout a course of action; (c) serve as criteria for the selection of materials to be presented to students; and (d) serve as standards by which the outcomes of instruction may be finally evaluated. The selection, organization, and presentation of subject matter should follow a psychological order; that is activities, experience, and materials should be planned and then taught in the time when the need for their use is most apparent. (p. 172)

To help determine early the tentative aims of a program, the Teske model provides for a job analysis to determine tasks and skills needed (job requirements) to develop curriculum objectives. This model is excellent for curriculum development and uses tasks to develop course objectives around job requirements. The Teske model is comprehensive and illustrates a sound approach to systematic development, implementation, and revision of curricula.

The Teske model does not adequately outline the activities related to a job analysis. The job-analysis function is outlined to determine the number and types of jobs available, necessity of training, amount and type of training needed, employment conditions,

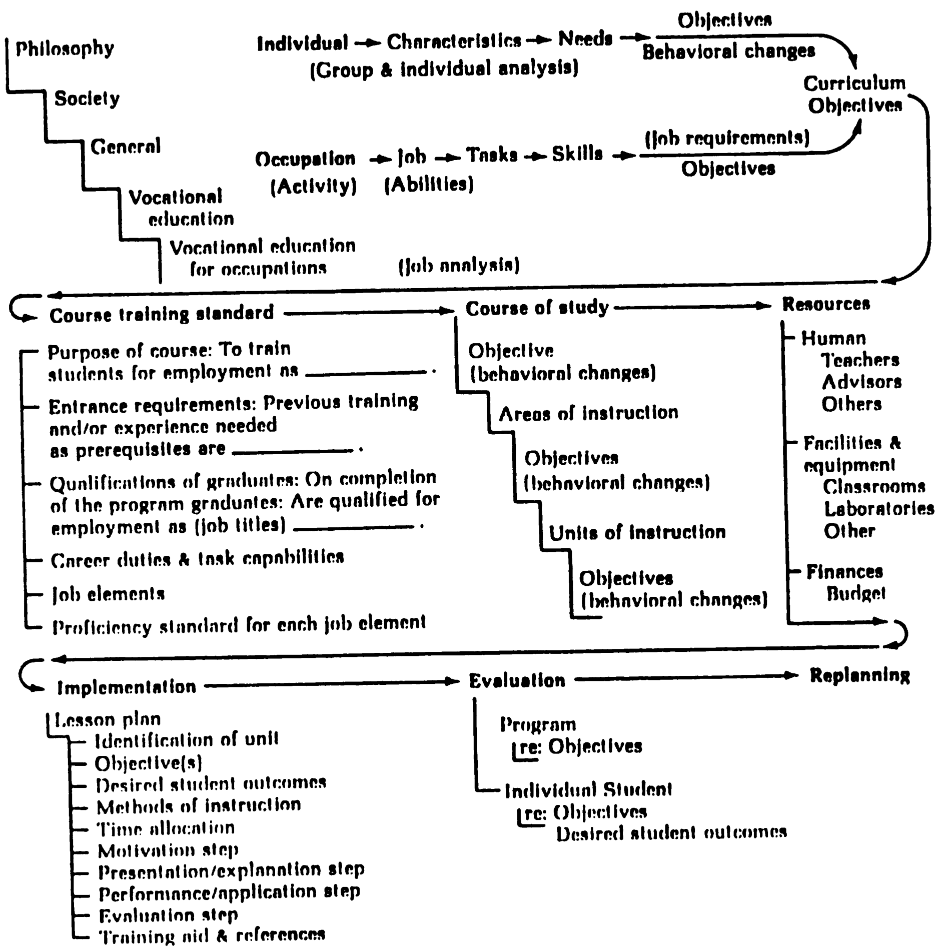

Figure 2.2: The Teske curriculum model. From C. C. Calhoun and A. V. Finch, Vocational Education Concepts and Operations (Belmont, Calif.: Wadsworth, 1982), p. 172.

and training needed for advancement. The model should incorporate a specific process for determining the tasks performed on the job and then clustering and sequencing those tasks into performance objectives.

Steely's Program-Development Process

The model developed by Steely (1981) includes five major aspects of program development: (a) informational sources, (b) curriculum design, (c) resource requirements, (d) program approval, and (e) program evaluation. (See Figure 2.3.)

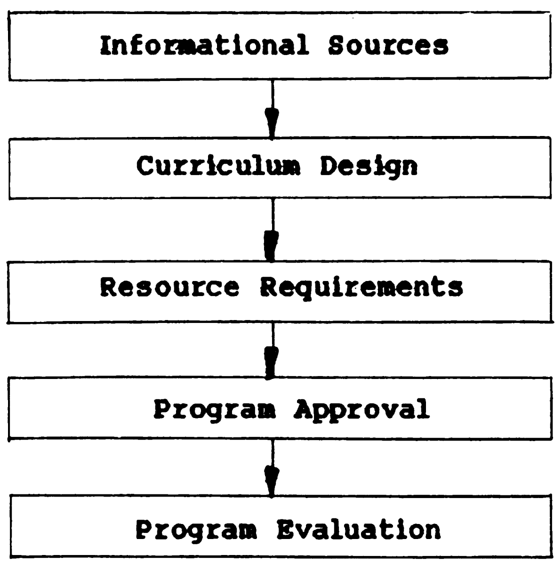

Figure 2.3: Steely's program-development process. From R. E. Steely, The Program Development Process Handbook (Project No. 3300-9152-43) (Lansing: Michigan Department of Education, 1981).

Step 1, informational sources, involves developing curriculum information by working with advisory committees, visiting companies, and working with professional organizations to develop an occupational job description (Steely, 1981, Chapter 1).

Step 2, curriculum design, is the design and development of a systematic process intended to prepare a person for identified occupations. The process involves the following six steps:

1. Perform an occupational analysis--A process that examines an occupation and documents the skills and knowledges which are required for successfully fulfilling the requirements of that occupation. . . . (p. 11)

2. Write program goals--Broad student-oriented action statements which identify the knowledge, skills, attitudes (tasks) a student will demonstrate before completion of an instructional program. . . . (p. 19)

3. Write performance objectives--Statements of instructional intent which describe in advance the performance a student will demonstrate at the completion of a learning experience. . . . (p. 22)

4. Write objective referenced tests--Testing which references and uses as its basis the stated performance objectives. . . . (p. 25)

5. Structure content into courses--A course is a major unit of a curriculum which is designed and is unique from all other major units and which is comprised of a number of related performance objectives. . . . (p. 28)

6. Write instructional strategies--The method used for delivery of instruction, including integration of facilities, equipment, instructional materials and teaching aids. . . . (Steely, 1981, p. 30)

Step 3, resource requirements, involves developing faculty and facility specifications, equipment, instructional supplies, and media specifications (Steely, 1981, Chapter 3).

Step 4, program approval, calls for securing internal and external approval to conduct the program (Steely, 1981, Chapter 4).

Step 5, program evaluation, entails establishing a method of program evaluation and developing a local plan for keeping the program current and on target (Steely, 1981, Chapter 5).

Steely's program-development process is an excellent curriculum model, of which occupational analysis is a key part. Step 2 (curriculum design) should be expanded to include clustering and sequencing the tasks after the occupational analysis is performed. This would provide a smooth transition for the development of student performance objectives.

The Center for Vocational Education Model: Steps in Developing a Course of Study

The model developed by the Center for Vocational Education (1978b) comprises nine basic steps in developing a course of study. (See Figure 2.4.) The Center for Vocational Education defined a course of study as

> a vital guide to instruction in a vocational program. . . . The course of study is in fact an official guide, or outline, which describes in broad terms a particular vocational program or specific course, its general objectives, the subject matter of the course, its general objectives, and the resources necessary for the achievement of the objectives. (p. 6)

The nine steps included in the model are discussed in the following paragraphs.

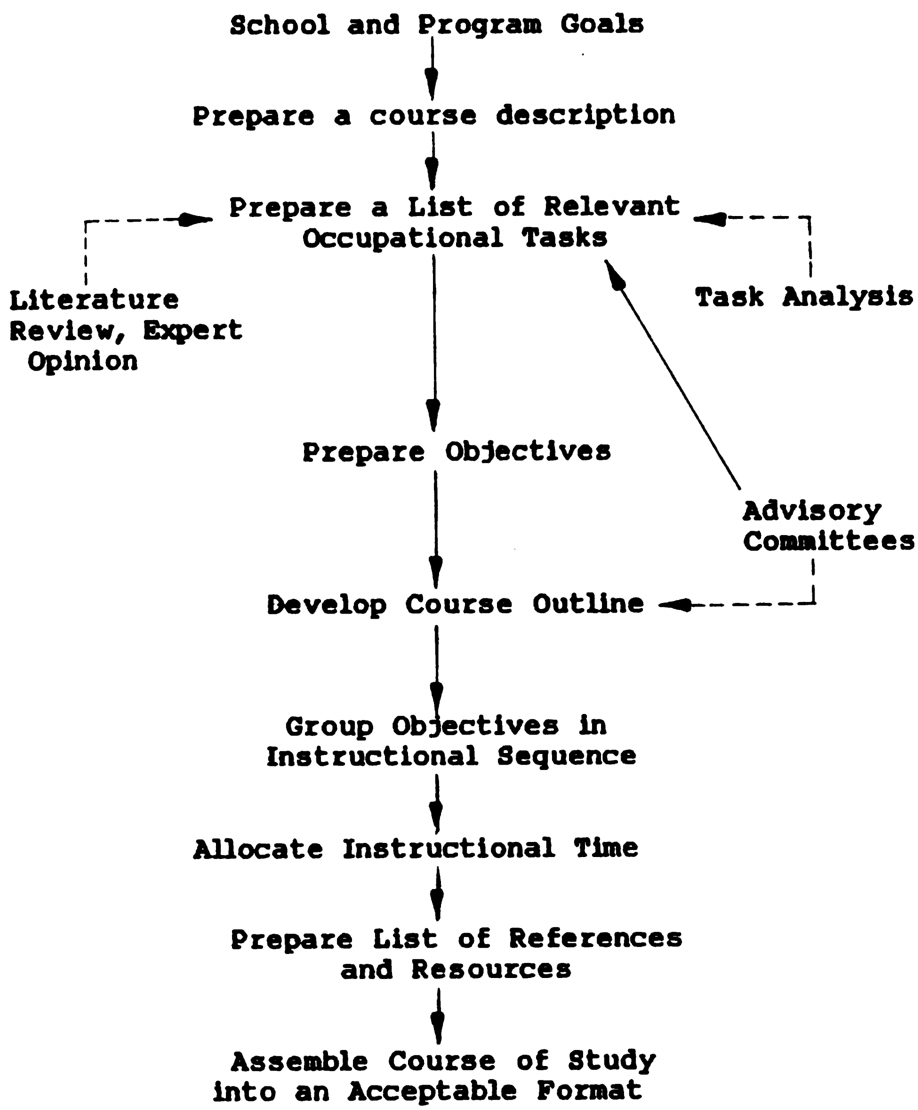

Figure 2.4: Steps in developing a course of study. From The Center for Vocational Education, The Ohio State University, Develop a Course of Study (Module A-8) (Columbus: National Center for Research in Vocational Education, The Ohio State University, 1978b).

Step 1: Prepare a course description, indicating the basic goals and purposes of the course. The purposes of a course evolve from the goals of the total program.

Step 2: Prepare a list of relevant occupational tasks appropriate to a course or program. The literature should be reviewed to identify existing task listings, and a formal occupational analysis should be performed. After the tasks have been identified, three basic questions should be asked:

1. Is the task actually performed by the level of worker you are going to train?

2. Is the task critical to the job success of this level of worker?

3. Is it feasible for the school to provide instruction on this task?

After developing a list of occupational tasks, one must organize these tasks into a logical learning sequence. The tasks should be grouped or clustered for instructional purposes. A cluster is a group of related tasks that should be taught together. A particular lesson or unit of instruction may cover just one task or more than one. The tasks or clusters of tasks then should be placed in a sequence, or order, to form the complete instructional program.

The following guidelines should be considered in the clustering and sequencing processes (Center for Vocational Education, 1978b):

> 1. Develop the sequence of tasks and topics by using the nature of the content as a guide. Progress from simple notions to complex principles, from basic tasks to those requiring a high level of skill. . . .

2. Consider the location of experiences and the resources required for various tasks. Some topics relate to subject matter knowledge that may be completed in the classroom; others require special laboratory facilities or unusual amounts of time; some may require on-the-job training. . . .

3. The ways in which students learn (the psychology of learning) suggest another consideration in sequencing and clustering tasks or topics. . . .

4. Consider the instructional and learning efficiency of grouping tasks. Tasks that have knowledge and other skill relationships, which can be readily learned together or are convenient to teach simultaneously should be grouped together. . . . (p. 27)

Step 3: Prepare the overall course objectives. These objectives should indicate in a general way what the student will be expected to do after completing the course.

Steps 4 and 5: Develop a course outline by clustering and sequencing the objectives into topics of instruction. The outline should be developed in a uniform manner, contain some indication of the occupational standards involved, and be sequenced in the most logical order.

Step 6: Allocate the instructional time that should be devoted to each unit of instruction.

Step 7: Prepare a list of all references and resources. This list should include needed textbooks, audio-visual materials, and tools and equipment.

Step 8: Assemble the course of study into an acceptable, readable, and understandable format.

This is an excellent program-development model, in which a task analysis is used to identify relevant occupational tasks for instructional purposes. A weakness of this model is the lack of program evaluation at the end. An evaluation step could be included as Step 9. This step would allow for both program and instructor review and provide a mechanism for program improvement.

Mager and Beach's Steps in
Course Development

The fifth model, designed by Mager and Beach (1967), outlines three phases for course development: (a) preparation phase, (b) development phase, and (c) improvement phase.

The steps in the course-preparation phase are designed to insure that all of the information and practice necessary to perform the job are included in a course. (See Figure 2.5.) These steps lead to the systematic derivation of course objectives, beginning with the job itself rather than content.

The first step is to develop a job description that tells what someone does when performing the job. The second step is to develop a list of tasks performed on the job (these tasks are identified through task analysis). The third step is to describe the student population. Then course prerequisites are prepared, primarily on the basis of the student description, and are adjusted to course objectives. Course objectives are derived primarily from task-analysis information; the are adjusted on the basis of course prerequisites and other constraints, such as time and facilities. The final step of the course-preparation phase is "developing measuring instruments (examinations) to measure the success of the student. Pre-and-post tests are developed" (Mager & Beach, 1967,

p. 4). This stage of the model could be improved by adding a step to cluster and sequence tasks.

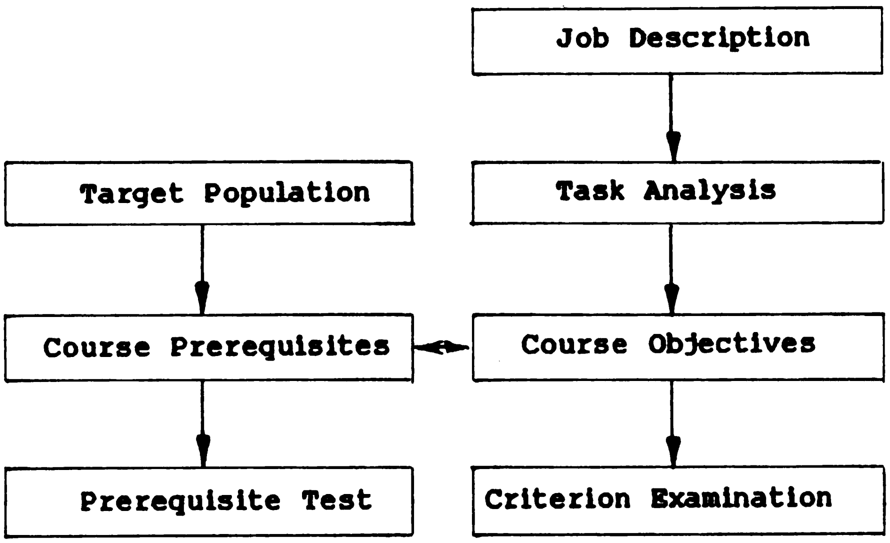

Figure 2.5: Steps in the course-preparation phase of Mager and Beach's model. From R. F. Mager and K. M. Beach, Developing Vocational Instruction (Belmont, Calif.: Fearon Publishers, 1967), p. 3.

The course-development phase (Figure 2.6) begins by outlining instructional units in terms of job tasks. At the end of each unit the student should be able to do something that he/she could not do before. The next step is to identify the type of performance associated with each step of the tasks so that intelligent decisions may be made about the instructional techniques needed to teach these tasks. Preliminary sequencing of the units is then carried out to maximize student skill and efficiency. Content is identified, and instructional procedures and materials relevant to each lesson are listed. A final sequencing is established, lesson plans are completed, and the course is ready for tryout.

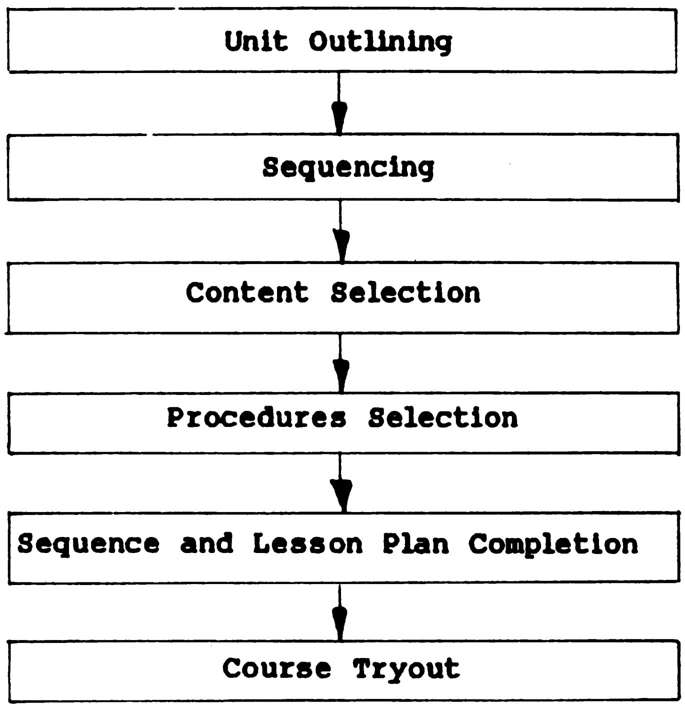

Figure 2.6: Steps in the course-development phase of Mager and Beach's model. From R. F. Mager and K. M. Beach, Developing Vocational Instruction (Belmont, Calif.: Fearon Publishers, 1967), p. 5.

The course-improvement phase (Figure 2.7) "builds in a process guaranteeing that the course will always be up-to-date. This phase checks to see if the objectives continue to meet the job" (Mager & Beach, 1967, p. 6).

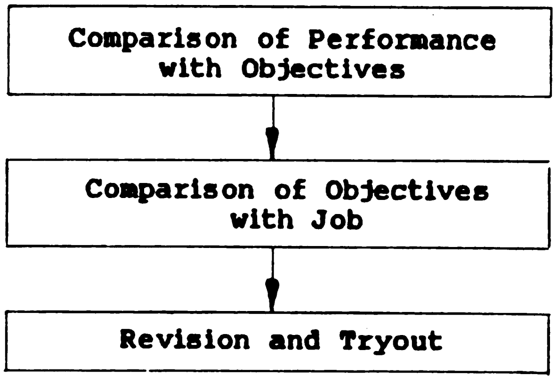

Figure 2.7: Steps in the course-improvement phase of Mager and Beach's model. From R. F. Mager and K. M. Beach, Developing Vocational Instruction (Belmont, Calif.: Fearon Publishers, 1967), p. 6.

Comparison of the Five Models for Use as a Program-Development Model

The five models discussed in the preceding section can all be used for developing vocational- or technical-education instructional programs. However, some models may work better than others at the program level. Both the Resnick and Teske models were developed as curriculum models and have a much broader scope than the other three. These models start with what Resnick called a population profile and general curriculum goals; Teske began with philosophy, society, general education, and vocational education.

The Mager and Beach model was designed as a course-development model and has a narrower focus than the other four. It addresses course prerequisites but does not deal with program goals. The model starts with a job description and proceeds to ensure all information and practice necessary to perform the job are included in a course.

The models designed by Steely and the Center for Vocational Education are designed for use at the program level, as defined in this study. The Center for Vocational Education model starts with school and program goals. The Steely model begins at the job level, where program goals are developed. These goals describe what the student should be able to demonstrate before completion of the program. The Steely model uses the term "curriculum" but defines it as "a series of courses or a sequence of instruction" (Steely, 1981, p. 10). Using the definition of terms in Chapter I, this definition resembles the explanation of "program" more than "curriculum.

These models all can be used to analyze occupations but employ different terms or approaches. The Resnick model uses a task-analysis subsystem to identify tasks for performance objectives to be used at the course level. The Teske model refers to a job analysis to identify skills and tasks needed to develop curriculum objectives. The Steely model uses an occupational analysis to identify duties and tasks needed to write program goals and student performance objectives. The Center for Vocational Education model calls for an occupational analysis to identify relevant tasks for developing course objectives. The Mager and Beach model uses a task analysis to identify tasks performed on the job as a basis for course objectives. All five models use job tasks as the foundation of objectives for course development.

Another difference in these models concerns evaluation. The Resnick model includes several evaluations during the process of development but does not incorporate an on-going evaluation process. The Teske model provides for reevaluation and replanning at the end, as does the Steely model with its program-evaluation process. The Mager and Beach model has a course-improvement section at the end. The Center for Vocational Education model offers no evaluation or course-improvement section.

Existing Duty and Task Statements for CAD/CAM Technicians

To this researcher's knowledge, no duty and task listings have been completed in the field of integrated CAD/CAM. Separate task listings have been compiled on CAD and CAM individually. Abram and Ashley (1983) and other researchers at the National Center for Research in Vocational Education conducted a research project on CAD/CAM. They wrote, "The term CAD/CAM is bandied about within both user and education circles, when in fact today almost all systems are CAD, or CAD manually linked to CAM" (p. 4).

Abram and Ashley did develop a duty and task listing for CAD and a duty listing for CAM. The CAD duty and task inventory list developed by Abram and Ashley (1983) is as follows:

1. <u>Operate System</u>
   Boot system/start up procedure
   Log in/on terminal
   Load start file
   Execute drawing assignment
   Manage files
   Plot out drawings
   Store a file
   Shut down a system
   Log off/out

2. <u>Execute Drawing Assignment</u>
   A. Change Existing Drawings or Details
      Plan drawing changes
      Find drawing file
      Load drawing file
      Execute changes
      Obtain approval/check drawing changes
      Plot out drawing
      Update file
   B. Document Original Designs
      Plan drawing layout
      Load start file
      Execute detailed drawings
      Obtain approvals
      Plot out drawing
      Store files
   C. Execute/Change Detailed Drawings
      Set up drawing format
      Create drawing components
      Confer with designer/engineer
      Compose drawings

3. <u>Compose Drawings</u>
   Understand and use system commands
   Create and manipulate geometry
   Select geometry
   Add text
   Rotate views
   Move views
   Scale views
   Dimension a drawing (p. 10)

Abram and Ashley also compiled the following CAM duty listing:

1. Analyze part geometry, materials, finish, and precision required.

2. Select machine types and tooling required.

3. Design and select hold-down jigs and fixtures.

4. Use a programming language to define finished part geometry and the geometry of the raw casting, bar stock, or other material. . . .

5. Determine tool path (feed rates, spindle speed, and tool selection) for most efficient use of a machine tool. . . .

6. Verify work against graphic representation on hard copy or CRT plotting devices.

7. Edit source program to correct errors or refine process.

8. Run post processes standardized file output to obtain machine image code in either punched tape or direct NC data file format.

9. Test run program in "dry run" mode. . . .

10. Machine prototype on a NC tool. . . .

11. Release program for production. . . . (pp. 22-23)

In his textbook entitled CAD/CAM Handbook, Teicholz (1985) listed the following job skills for people who used CAD equipment in their work in a graphics department:

1. Systems Start-up and Shut-down
   a. System power up and initial boot up. . . .
   b. Regular log-in procedure
   c. Crash recovery procedures
   d. Nightly shutdown of all systems

2. Part Naming Convention
   a. Coping and moving a part
   b. Multiple sheet drawings
   c. Part construction phase
   d. Checking phase
   e. Revision phase
   f. Release phase
   g. Experimental phase
   h. Production phase

3. Drawing Conventions and Techniques
   a. Developing a construction strategy. . . .
   b. Filling procedures
   c. Units and scale
   d. Layering. . . .
   e. Saving and restoring display images. . . .

f. Formats. . . .
g. Geometric construction
h. Layout and construction techniques. . . .
i. Detail construction techniques. . . .
j. Assembly-drawing techniques. . . .
k. Sectioning. . . .
l. Dimensioning. . . .
m. Decals, charts, notes, symbols, geometry
n. Plotting. . . .

4. Drawing Route Flowchart

5. Location of Most Current Version of a Part
   a. Search over network architecture
   b. Search of all system nodes
   c. Search of archival files

6. Engineering Change Procedure

7. Operator Responsibility
   a. Maintenance
   b. Meetings

8. Forms

9. Database Maintenance
   a. Check data base
   b. Pack data base
   c. Sorting the data base
   d. Regenerate graphics
   e. Dealing with problem part. . . . (pp. 8.18-8.21)

The Ministry of Colleges and Universities (1982) in Ontario, Canada, developed a DACUM chart on a numerical control/computer numerical control (NC/CNC) programmer. (An NC/CNC programmer is the same as a CAM programmer.) The general areas of competence identified in this DACUM chart are as follows:

1. Determine manufacturing method.

2. Generate manual part programs.

3. Generate computer-assisted part program.

4. Supervise program and tool proving.

5. Create and maintain files and records.

6. Trouble-shoot NC-related problems
7. Research and implement new technology.
8. Generate part program using CAD/CAM system.

Summary

Five methods of analyzing an occupation were discussed in this chapter. These methods were the DACUM, the function approach, the occupational analysis, the critical-incident technique, and the Delphi technique. The unique strengths and weaknesses of each method were also discussed.

Strategies for using occupational-analysis data to develop curricula were outlined. Five models were discussed, all of which used occupational-analysis data for instructional purposes. The five models were Resnick's curriculum model, Teske's curriculum model, Steely's curriculum model, a course-development model designed by the Center for Vocational Education at The Ohio State University, and Mager and Beach's course-development model. These models were compared and contrasted, as well.

The chapter included a CAD duty and task list and a CAM duty list developed by Abram and Ashley at the National Center for Research in Vocational Education. Teicholz's list of CAD duties and tasks and a DACUM profile of the occupation of CNC/NC programmer were also included. However, the researcher discovered no integrated CAD/CAM duty and task list.

CHAPTER III

DESIGN OF THE STUDY

The methods used in carrying out the study are explained in this chapter. The discussion focuses on two topics: (a) selection of the method of analysis used to conduct this study and (b) the method used to answer each research question.

Selection of the Method of Analysis

The literature review showed that several methods can be used to analyze an occupation. The method chosen depends on the researcher's objectives. The objectives of the present study were:

1. To provide a functional definition of the emerging occupation of CAD/CAM technician.

2. To identify and list the duties and tasks performed by CAD/CAM technicians. Emphasis was given to the CAD/CAM hardware and software, but attention also was given to industrial applications of the CAD/CAM system.

3. To identify the frequency with which each task is performed and to determine the relative importance of each task for job entry.

4. To identify program-development models for using the products of an occupational analysis.

5. To provide a program-development model and guidelines for using the products of this occupational analysis to develop programs to train CAD/CAM technicians.

The method chosen to meet the research objectives was occupational analysis. The process used in this study was modeled after the analysis method used by the Center for Vocational Education (1978) because it provides not only a task listing but also a detailed rating of the tasks in terms of frequency with which they are performed and the importance of the tasks for job entry. These ratings provide a means to rank the tasks so a program can be designed to meet the needs of students in the time allotted.

This method of occupational analysis also provided an opportunity to use the interview method to obtain the data required for this study. Gordon (1969) listed five advantages of the interview over a mailed questionnaire:

1. The interview provides more opportunity to motivate the respondent to supply accurate and complete information immediately.

2. The interview provides an opportunity to guide the respondent in his/her interpretation of the questions.

3. The interview provides greater flexibility in questioning the respondent.

4. The interview provides an opportunity to evaluate the validity of the information by observing the respondent's nonverbal manifestations.

5. The interview allows greater control over the interview situation. The respondent answers the questions in sequence and is not influenced by subsequent questions.

Another reason for selecting the occupational-analysis method is the fact that a task-based curriculum is the preferred curriculum-development method for both secondary vocational education and community college technical education programs in Michigan.

The DACUM approach is not thorough enough to identify the frequency with which tasks are performed or the importance of the tasks for job entry, nor would it provide the number of people or industrial representation that an occupational analysis provides. The Delphi method would be too time consuming for both the researcher and the technicians. This researcher believed that technicians would not be willing to rate a large number of task statements in four rounds of questionnaires. The function approach to curriculum development is too broad to define one job title and takes considerable time and resources to execute. The critical-incident method is not task based and thus did not meet the needs of this study.

Methods Used to Answer the Research Questions

Research Question 1

The first research question (What is a functional definition of the occupation of CAD/CAM technician?) was answered through a jury technique, which incorporated the following steps:

1. Reviewing related job descriptions. The following job descriptions were reviewed to provide a foundation for the first description of the occupation of CAD/CAM technician used in the preliminary questionnaire of this study:

A. Mechanical Drafter (Dictionary of Occupational Titles, 1977, 007.281-010)

B. Numerical-Control Machine Operator (Dictionary of Occupational Titles, 1977, 606.662-010)

C. Tool Programmer, Numerical Control: Job description for General Motors Metal Fabrication Plant, Grand Rapids, Michigan

D. CADAM Operator: Job duties and responsibilities for Frost, Inc., of Grand Rapids, Michigan

E. Computer Drafting and/or Graphics Technician: Job description from the National Center for Research in Vocational Education at The Ohio State University (Russell, 1981)

2. Reviewing the literature. As indicated in the literature review, existing duty statements were reviewed in the fields of CAD, CAM, and CNC/NC programmer.

3. Developing a preliminary job description. The researcher developed a preliminary job description after reviewing the pertinent literature and existing job descriptions.

4. Pilot testing the job description. The preliminary job description was reviewed by two Grand Rapids Junior College instructors: (a) a CNC and CAM instructor and (b) a CAD and CAD/CAM instructor.

5. Developing a questionnaire. Based on the preliminary job description and input from the two junior college instructors, a

questionnaire was developed with which jury members would review the job description.

6. Distributing the questionnaire to the jury. Seven experts in the field of CAD/CAM were contacted by telephone to see if they would be willing to participate in the study. These experts represented a cross-section of industrial users of CAD/CAM systems. The researcher gave them a brief overview of what they would be expected to do with the questionnaire. The instruments were mailed to the jury of experts. These individuals reviewed the job description and were asked to modify, add, and/or delete items.

7. Analyzing the questionnaire responses. The researcher reviewed the responses to the first questionnaire and developed a revised job description.

8. Distributing the revised job description. A revised job description was mailed to the original seven experts for their ratings. The rating scale was as follows: (5) excellent, (4) good, (3) acceptable, (2) below average, (1) not acceptable.

9. Recycling. An updated job description was mailed to the original seven experts for their ratings. The criterion established for acceptance of the job description was a rating of 2.5 or above.

10. Writing a final job description. Following the jury process, the researcher wrote a final job description.

Research Question 2

The second research question (With emphasis given to the CAD/CAM hardware and software and attention to the industrial applications of the systems, what are the duties and tasks performed by CAD/CAM technicians operating these systems?) was answered by performing the following steps:

1. Reviewing operating manuals of CAD/CAM systems to develop appropriate duty and task listings. The following manuals for operating CAD/CAM equipment were reviewed: (a) Finite Element Modeling Reference Manual: Mechanical Design (Computervision, 1983); (b) Numerical Control (NC) Reference Manual (Computervision, 1982); and (c) Inside AutoCAD (Raker, 1985).

2. Reviewing duty and task statements from existing occupational analyses. The following task lists were reviewed, as discussed in Chapter II: (a) NC/CNC Programmer (Ministry of Colleges and Universities, Ontario, Canada, 1982); (b) Numerical Control Machine Tool Programmer (Nolan, n.d.); and (c) CAD and CAM task listings (Abram & Ashley, 1983).

3. Reviewing textbooks in the field of CAD/CAM to develop duty and task statements. The following related textbooks were reviewed: Flexible Automation (Kief, 1985), The CAD/CAM Handbook (Machover & Blauth, 1980), CAD/CAM Handbook (Teicholz, 1985), and Introduction to CAD (Vosinet, 1985).

4. Developing duty statements from the researched materials. After reviewing the materials listed in Steps 1, 2, and 3, duty statements were developed. These statements were then reviewed and modified by the following four college instructional staff members and two incumbent workers: (a) a CAD instructor at Grand Rapids Junior College; (b) two electronics instructors at Grand Rapids

Junior College; (c) a CAD/CAM night supervisor/operator at Frost, Inc., Grand Rapids, Michigan; (d) a CAM instructor at Grand Rapids Junior College; and (e) a CAD/CAM operator at CPC General Motors, Grand Rapids, Michigan. After reviewing the input from the six experts, the researcher developed a final list of duties.

5. Preparing task statements for each duty statement. After writing the duty statements, the researcher compiled an initial list of tasks, based on the information gathered in Steps 1 through 4.

6. Organizing the duty and task statements into a preliminary inventory. The researcher completed a final sequencing of tasks. He organized the tasks by clustering related tasks and ordering them in the sequence in which they are performed on the job.

7. Conducting personal interviews (pilot testing the inventory) with a selected group of CAD and CAM educators and incumbent CAD/CAM operators or supervisors. The six professionals listed in Step 4 reviewed the initial task inventory and made suggestions for revising the task listing.

8. Revising the inventory based on information received during the interviews. After the six professionals reviewed the initial task inventory, the researcher compiled a task list for field testing.

9. Developing an interview schedule that included the duty and task statements, with provisions for rating frequency performed and importance for job entry. The researcher developed an interview schedule for this phase of the study. The instrument had four

sections. The first was a letter of introduction, and the second was a consent form. The third section included a series of general questions for the CAD/CAM technicians to answer. The fourth section contained a complete duty and task analysis check sheet.

10. Selecting a sample of incumbent CAD/CAM technicians and supervisors. A stratified sample of CAD/CAM technicians and supervisors was drawn from a target population of technicians who operated or supervised the operation of common CAD/CAM systems for a variety of industrial applications. To be included in the study, individuals had to have had at least six months of experience in the field.

Through a review of the literature and interviews with CAD/CAM salespeople who served southern Michigan, the following data were collected about the target population:

A. The automotive industry is a large user of CAD/CAM systems. Ford, General Motors, Chrysler, and their suppliers are all heavy users of CAD/CAM systems (Krouse, 1986b).

B. A salesman from Computer vision reported by letter on June 13, 1986, that "approximately 47 sites in Southern Michigan are performing CAD/CAM operations. Thirty of these sites are automotive, ten are nonautomotive, five deal in the plastics field which could be both automotive and nonautomotive, and two in the electronics field." He also said IBM had the most CAD/CAM systems installed in Michigan at this time and that Computervision had the second most installations.

C. An IBM salesman reported during a phone interview on June 6, 1986, "The automotive industry was IBM's largest user of

CAD/CAM systems in southwestern Michigan, with companies like Rochester Products of Grand Rapids, Motor Wheel in Lansing, and Oldsmobile of Lansing all using IBM systems."

D. A CAD instructor from Macomb Community College reported during a phone interview on July 14, 1986, "The prime CAD/CAM system is one of the most popular systems in the Detroit area because Ford uses this system and there are many tool and die shops, etc., that are doing work for Ford in the Detroit area."

E. A salesman from Intergraph reported during a phone interview on June 6, 1986, "Intergraph has approximately 60 installed systems in Michigan." He felt most systems are used in the automotive field, but there are also many nonautomotive applications, including Greenville Products and Belding Products in the Grand Rapids area. He also felt IBM had the most installed systems in Michigan at that time.

F. John Krouse (1986b) reported that, in 1986, four large computer companies accounted for 54% of the installed CAD/CAM systems. (See Table 3.1.) Krouse (1986a) also reported that there were 12 up-and-comers in the CAD/CAM market in 1986. (See Table 3.2.)

The Computer and Automated Systems Association (1986), a division of the Society of Manufacturing Engineers, published a list of CAD/CAM vendors that included the following companies: Applicon, Auto-Trol, Calcomp, GE Calma, Computervision, CompuTool, Control Data, Data General, Digital Equipment Company (DEC), Evans and

Table 3.1.--Installed CAD/CAM systems in the United States in 1986.

Company	Share of the Market
International Business Machines (IBM)	21%
Intergraph	15%
Computervision	12%
GE Calma	6%
Other major systems	46%
McDonnell Douglas	
Prime	
Control Data	
Hewlett-Packard	

Source: J. Krouse, "PCs, Solid Modeling Drive CAD/CAM Sales," High Technology (March 1986): 44.

Table 3.2.--Up-and-comers in the CAD/CAM market in 1986.

Company
Alias Research
AUTODESK (AUTOCAD) (PC based)
Automaton Technology Products (ATP)
Celerity Computing (ANSYS, PATRAN, and NASRAN)
CIMLINC
Cognition (PC based)
Cubicomp (PC based)
Graftek
Matra Datavision
MEGACADD (PC based)
Tasvir (PC based)
T & W Systems (PC based)

Source: J. Krouse, "Engineering Without Paper," High Technology (March 1986): 42.

Sutherland, Gerber, Hewlett-Packard, IBM, Intergraph, Lockheed, McDonnell Douglas (MCAuto), Prime, Summagraphics, T & W, and Tecktronix.

The study population represented technicians operating different types of CAD/CAM systems in both the automotive and the nonautomotive industries in southern Michigan. A stratified sample was drawn from this population. The research was originally designed to reflect the dominance of IBM, Intergraph, and Computervision system installations. However, during interviews with some of the Intergraph users (Steelcase in Grand Rapids, Michigan; Greenville Products in Greenville, Michigan; and Belding Products in Belding, Michigan), the researcher found that even though CAD/CAM systems were installed they were not linking CAD to CAM. These systems were being used solely for product designing, and the technicians were not downloading any of their design information to manufacturing tools.

The researcher also discovered that the Prime system was used extensively in southeastern Michigan. To provide a better representation of current CAD/CAM users in Michigan, the sample included a larger percentage of Prime users and a smaller percentage of Intergraph users than those indicated in Crouse's (1986b) national research. Eight other CAD/CAM systems were also represented in the study. The researcher selected those systems based on availability of technicians operating them in southern Michigan.

A second consideration in selecting the sample was the industrial applications of these systems. Two levels of applications were represented in the sample. The first level comprised technicians who worked only on automotive products; the second comprised those who worked only on nonautomotive projects and those who worked on both automotive and nonautomotive projects. The second level is hereafter referred to as "nonautomotive." The following Standard Industrial Classification (S.I.C.) codes were used to help classify companies:

1. Automotive industry application

   a. S.I.C.: 3079 Plastics products misc.
   b. S.I.C.: 3325 Foundries steel misc.
   c. S.I.C.: 3465 Stamping auto
   e. S.I.C.: 3499 Metal products fabricated
   f. S.I.C.: 3542 Machine tools, metal forming
   g. S.I.C.: 3544 Tools & dies, jigs and fixtures
   h. S.I.C.: 3711 Motor vehicle and car bodies
   i. S.I.C.: 3714 Motor vehicle parts and accessories

2. Nonautomotive application

   a. S.I.C.: 2521 Furniture office wood
   b. S.I.C.: 2522 Furniture office metal
   c. S.I.C.: 3079 Plastics products misc.
   d. S.I.C.: 3494 Valves and pipe fittings
   e. S.I.C.: 3535 Conveyors and equipment
   f. S.I.C.: 3559 Machinery special
   g. S.I.C.: 3562 Bearings, ball and roller
   h. S.I.C.: 3569 Machinery, general industrial
   i. S.I.C.: 3599 Machinery, misc.
   j. S.I.C.: 3732 Boats other
   k. S.I.C.: 3728 Aircraft equipment
   l. S.I.C.: 3764 Space propulsion
   m. S.I.C.: 3823 Instruments, process control
   n. S.I.C.: 3829 Measuring and controlling devices
   o. S.I.C.: 3825 Instruments, electrical measuring

To reflect the dominance of the use of CAD/CAM systems in the automotive industry, a larger percentage of technicians and supervisors from the automotive industry were selected to participate than were those from nonautomotive and a combination of automotive and nonautomotive industrial projects.

The names of companies and technicians or supervisors to contact were obtained in several ways. Most company names were obtained by interviewing salesmen from the various CAD/CAM vendors. The salesmen were told the research objectives and asked if they would provide names of companies and contact potential interviewees in those companies. Some community college staff who were teaching in the field of CAD/CAM were also contacted for a list of companies using CAD/CAM systems in their district.

11. Verifying the inventory by interviewing incumbent CAD/CAM technicians and supervisors. The researcher telephoned the companies suggested by salesmen and community college staff. Normally the call was directed to a supervisor or technician in the CAD/CAM department. The telephone procedure the researcher used is shown in Figure 3.1.

Interview dates were set, and the interviews were conducted. Interviewees were asked to respond to each statement on the checklist in terms of: Is the task performed (yes or no)? How frequently is the task performed (daily, weekly, monthly, less than monthly)? Is the task required for job entry (essential, very desirable, desirable, unnecessary, not sure)?

Interviewees were also asked a series of general questions designed to elicit the following information: their name, job title, company name, work phone, how long they had worked as a CAD/CAM technician, how long they had supervised CAD/CAM technicians, the type of CAD/CAM system they were operating, the industrial application of their CAD/CAM system work (automotive or nonautomotive), and whether they thought generic CAD/CAM machine/software training was sufficient for job entry.

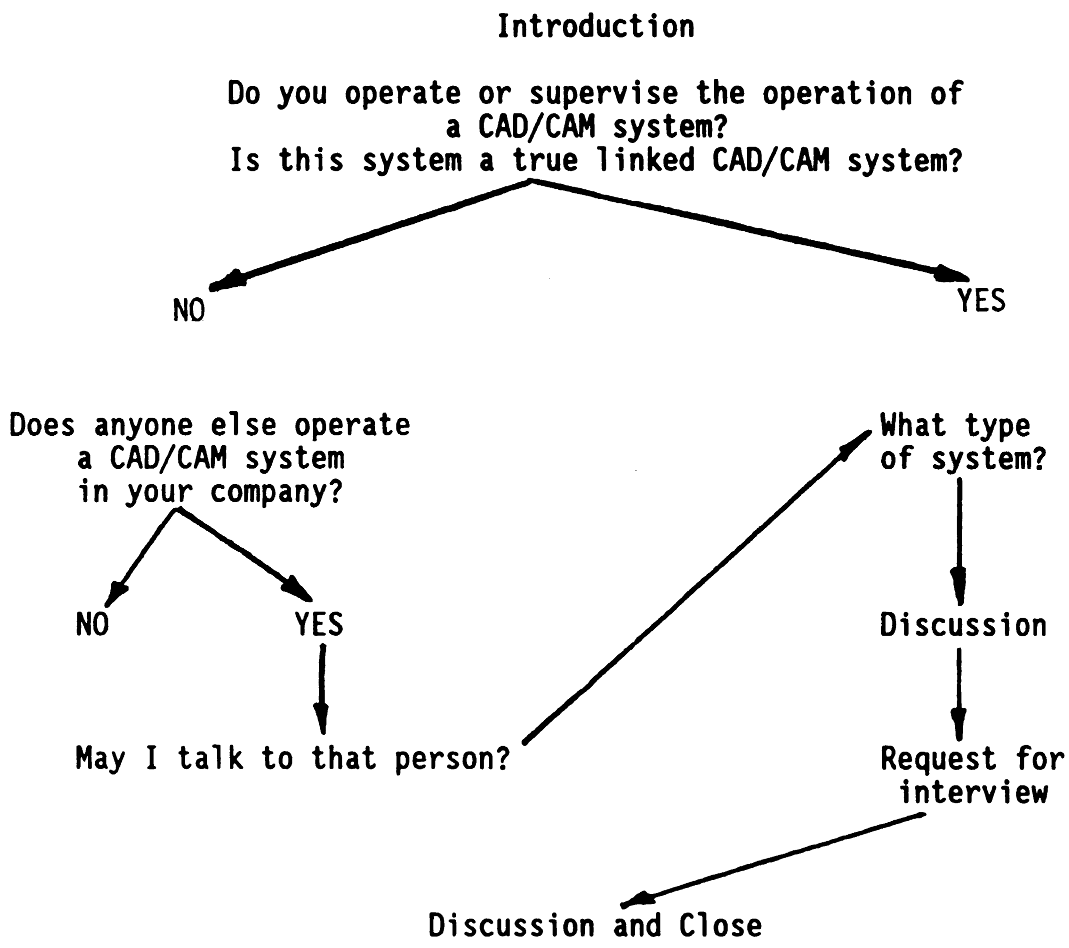

Figure 3.1: Telephone procedure used in attempting to identify CAD/CAM technicians and supervisors to interview.

Sequential sampling was used to determine the sample size (Fox, 1969). The data from two sets of 18 questionnaires each were tabulated and compared. When the researcher determined that there was no appreciable difference between the two samples and that additional data would not provide new insights for the study, no additional interviews were conducted.

12. Categorizing and displaying the data in tables. The data were organized into tables, as follows:

A. A table comparing the responses of CAD/CAM technicians who used their systems for different industrial applications. This table compares the responses of CAD/CAM technicians who were using their equipment in automotive and nonautomotive applications to the question: Do you perform this task?

B. A table listing the tasks that met the established research criteria. A performance criterion of 50% was established as a cutoff. Tasks performed by less than 50% of the CAD/CAM technicians were omitted from the final list. The researcher selected the 50% cutoff as a "realistic criterion," based on the suggested criterion of 50% established by the Center for Vocational Education (1978a). A separate list of the duties and tasks that did not meet the criterion is also provided.

C. A table ranking the tasks according to frequency with which they are performed.

D. Two tables comparing the performance ratings of the tasks as given by participants from the automotive and nonautomotive industries. Both an F-test (analysis of variance) and a t-test will be used to determine if there is a significant difference between the level at which the tasks are performed by the two groups. Task mean scores are compared by duty area. This table was constructed to illustrate which tasks are performed or not performed equally by CAD/CAM technicians in the automotive and nonautomotive industries. Such information could help in determining the importance of teaching certain duties for both the automotive and nonautomotive industries if it is found that a relationship exists between the importance of a task to job entry and level of performance of that task.

Research Question 3

The third research question (What tasks are most frequently performed by a CAD/CAM technician, and which tasks are the most important for a technician to be able to perform at job entry?) was answered by organizing and presenting the data collected using the following tables and calculations:

A. A table listing the frequency with which each task is performed. The numerical value assigned to each frequency category is as follows: less than monthly (1), monthly (2), weekly (3), and daily (4). The table shows the number of times each category was chosen, as well as the mean frequency score of each task.

B. A table listing the rating of importance of each task for job entry. The value assigned to each level of importance is as follows: essential (4), very desirable (3), desirable (2), unnecessary (1), and not sure (0). The table includes the number of times each category was chosen and the mean importance score of each task.

C. A table showing the correlation between frequency with which each task is performed and the level of importance of that task for job entry. Pearson's r was used in calculating these correlations.

D. Two summary tables ranking the tasks that met the criterion established in this research. In the first table, tasks are ranked from highest to lowest importance for job entry. In the second table, tasks are ranked from highest to lowest frequency of performance. In formulating these tables, the researcher reviewed the data and omitted any tasks that did not meet the "realistic criterion" established by the researcher, following the guidelines of the Center for Vocational Education (1978a).

The abovementioned tables are included in Chapter IV and in Appendices J through M.

Research Question 4

The fourth research question (What program-development models can be identified for using the products of this occupational analysis?) was answered by:

1. Reviewing the literature and other sources to identify strategies for using occupational-analysis data to develop a

curriculum. Chapter II contained a discussion of models that use such data for instructional purposes.

2. Synthesizing the information for application to this study.

Summary

Occupational analysis was the method selected for the study. The purpose of conducting an occupational analysis was consistent with the main focus of this study. The methods and procedures used in addressing each research question were described in detail in this chapter. Chapter IV contains the results of the study.

CHAPTER IV

FINDINGS

This chapter presents the findings of the surveys and interviews of CAD/CAM technicians to determine a functional job definition and task listings in addressing Research Questions 1, 2, 3, and 4.

Findings for Research Question 1

Research Question 1: What is a functional definition of the occupation of CAD/CAM technician?

The first research question was answered through a jury technique as explained in Chapter III. The findings for each step of the jury process are as follows.

1. Related job descriptions. Five related job descriptions were reviewed:

A. Mechanical Drafter (Dictionary of Occupational Titles, 1977, 007.281-010). A person who drafts detailed working drawings of machinery and mechanical devices, indicating dimensions and tolerances, fasteners and joining requirements, and other engineering data. A draftsperson also drafts multiple view assembly and subassembly drawings as required for manufacturing and repair of mechanisms.

B. Numerical Control Machine Operator (Dictionary of Occupational Titles, 1977, 609.662-010): Sets up and operates multipurpose numerically-controlled machines to perform any combination of machining operations, such as milling, drilling, reaming, or broaching metal work pieces to specifications. Reviews set-up sheet and specifications to determine sequence of set-up operations and dimensions of finished work piece. . . (p. 511).

C. Tool Programmer, Numerical Control (Job Description for General Motors Metal Fabrication Plant, Grand Rapids, Michigan): Plans numerical control program to control contour-path machining of parts on automatic machine tools by means of magnetic or perforated tape. Analyzes part drawings, sketches, and design data to determine dimensions and configuration of cuts, selecting cutting tools, machine speeds and feeds, according to knowledge of machine shop processes. Prepares geometric layouts on graph paper to show location of reference points and direction of cutting paths, using drafting instruments. Writes instruction sheets and cutter lists to guide set-up and operation of machines.

D. CADAM Operator (a listing of job duties and responsibilities from Frost, Inc., Grand Rapids, Michigan):
   a. Responsible for the proper and correction input of engineering drawings into the CADAM data base.
   b. Must be capable of planning time both daily and over the term of a project.
   c. Organization and cleanliness of work area should be maintained.
      aa. Work surface
      bb. Plotter and pens
      cc. Terminals
   d. Responsible for operation of plotter.
   e. Knowledge of system back-up, power on procedures.
   f. Assist and suggest options in the design of new or existing products.
   g. Responsible for being able to think through problems and come to solutions by using the documentation and resources available.
   h. Must be able to work flexible hours in a functional management environment with little direct supervi sion.

E. Computer Drafting and/or Graphics Technician (Russell, 1982): Computer-oriented interactive graphics represents the combination of a computer and a graphics output (and input) device as a medium by which a user manipulates visual information. The end result may be the design of an automobile, the teaching of a lesson in electromagnetic field theory, the training of an airplane pilot, entertainment such as animated cartoons, or the manipulations of colors, masses, and forms to produce purely artistic designs (p. 22).

2. Reviewing the literature. A review of the literature was conducted to identify existing duty listings for CAD, CAM, and CAD/CAM. Four such lists were found in the literature. The first list of CAD duties came from a duty and task inventory developed by Abram and Ashley (1983):

1. Operate System
2. Execute Drawing Assignment
   A. Change Existing Drawings or Details
   B. Document Original Designs
   C. Execute/Change Detailed Drawings
3. Compose Drawings (p. 10).

The second list is a CAM duty list developed by Abram and Ashley (1983):

1. Analyze part geometry, materials, finish, and precision required.
2. Select machine types and tooling required.
3. Design and select hold-down jigs and fixtures.
4. Use a programming language to define finished part geometry and the geometry of the raw casting, bar stock, or other material. . . .
5. Determine tool path (feed rates, spindle speed, and tool selection) for most efficient use of a machine tool. . . .
6. Verify work against graphic representation on hard copy or CRT plotting devices.
7. Edit source program to correct errors or refine process.
8. Run post processes standardized file output to obtain machine image code in either punched tape or direct NC data file format.
9. Test run program in "dry run" mode. . . .

10. Machine prototype on a NC tool. . . .

11. Release program for production. . . . (pp. 22-23)

The third is a duty listing from a duty and task list compiled by Teicholz (1985):

1. Systems Start-up and Shut-down
2. Part Naming Convention
3. Drawing Conventions and Techniques
4. Drawing Route Flowchart
5. Location of Most Current Version of a Part
6. Engineering Change Procedure
7. Operator Responsibility
8. Forms
9. Database Maintenance

The fourth list is a DACUM chart of a NC/CNC programmer's duties developed by the Ministry of Colleges and Universities (1982) in Ontario, Canada:

1. Determine manufacturing method
2. Generate manual part programs
3. Generate computer-assisted part program
4. Supervise program and tool proving
5. Create and maintain files and records
6. Trouble-shoot NC related problems
7. Research and implement new technology
8. Generate part program using CAD/CAM system

3. Developing a preliminary job description. After reviewing the literature and the related job descriptions, the researcher developed a preliminary job description for purposes of this study.

4. Pilot testing the job description. The preliminary job description was reviewed and modified by two Grand Rapids Junior College instructors (one teaches CNC and CAM, and the other teaches CAD and CAD/CAM). Based on this review, the following job description was developed:

> A CAD/CAM technician is the person who operates a CAD computer terminal that transmits data to a CAM data base or machine tool. He/she is responsible for manipulating mechanical drawing information, generating part programming information, performing data base maintenance and is normally required to handle day-to-day administrative activities as:
>
> a. daily and weekly file management
> b. daily operation and maintenance of the printer and plotter
> c. administration of manufacturing procedures
> d. answering other (CAD, CNC, CAM) operator questions
> e. assisting in training other CAD/CAM technicians
> f. assisting in the design of new and existing products and/or manufacturing processes

5. Developing a questionnaire. A questionnaire was developed for the jury to review the job description. This questionnaire asked jury members to modify the job description sentence by sentence. They could also make additions or deletions to the description. (See Appendix A for a copy of the questionnaire.)

6. Distributing the questionnaire to the jury. Seven experts in the field of CAD/CAM reviewed the job description. They were asked to modify the description as they saw fit. (See Appendix B for the list of CAD/CAM experts.) These experts included:

A. One small CAD/CAM job shop president/system operator who worked with both automotive and nonautomotive products.

B. One supervisor from the electronics (nonautomotive) industry.

C. One supervisor and one CAD/CAM operator/night supervisor from the materials-handling industry.

D. One supervisor from the plastics field (automotive and nonautomotive).

E. Two CAD/CAM supervisors from the automotive industry.

These experts were chosen because of their supervisory positions in the field of CAD/CAM and because they represented a variety of industries. The seven experts offered the following recommendations and insights:

A. The size of the firm, or CAD/CAM department, will affect the job responsibilities of the CAD/CAM technician. In a small firm the technician may do file management and system and plotter maintenance. In large firms there normally are people assigned to system operations to perform only this function.

B. A CAD/CAM technician is a person who uses standard practices for the operation and creation of engineering data through a CAD/CAM work station.

C. Daily administrative activities include (a) revising drawings and creating new drawings and (b) assisting in the design of new or existing products.

D. A CAD/CAM technician is a person who operates a CAD terminal that creates, edits, and/or transfers an electronic data base for use in a CAM environment (i.e., CAM data base or machine tool).

E. A CAD/CAM technician is a person who plans numerical control programming to control contour path machining of parts on automatic machine tools by means of magnetic or perforated tape. Analyzes part drawings and sketches and designs data to determine dimension and configuration of cuts, selects cutting tools and machine shop processes. Determines machine cutter paths and observes operation of CNC machine on a trial run to prove taped instructions.

F. CAD/CAM technicians just generate tool paths for CNC machinery, and administrative duties are done by others.

7. Analyzing the questionnaires. After reviewing the input from the seven CAD/CAM technicians, the researcher prepared a final job description. (See Appendix C.) The following rating scale was developed for the CAD/CAM experts to use in rating the final job description: (5) excellent, (4) good, (3) acceptable, (2) below average, (1) not acceptable.

8. Distributing the revised job description. The researcher mailed the revised job description to the seven CAD/CAM technicians. The job description read as follows:

> A CAD/CAM technician is a person who operates a CAD (Computer-Aided Design) computer terminal to create, edit, then transfer engineering data to a CAM (Computer-Aided Manufacturing) data base or machine tool. A CAD/CAM technician is responsible for analyzing part drawing data, sketches, and design data. CAD/CAM technicians also generate part program information, perform data base maintenance, and are normally required to handle day-to-day administration activities as:

a. Daily and weekly file management
b. Operate and maintenance of plotter, pens and of terminals
c. Answer other (CAD, CNC, and CAM) operator questions
d. Administration of manufacturing procedures
e. Assist in training other CAD/CAM technicians
f. Assist in the design of new and existing products and/or manufacturing processes

The seven CAD/CAM technicians' ratings of the job description are shown in Table 4.1.

Table 4.1.--Technicians' ratings of the job description.

No. of Technicians	Rating	Points
2	Excellent (5)	10
5	Good (4)	20
Total 7	Mean 4.28	30

9. Recycle. All seven technicians gave the description above a 2.5 rating (acceptable), so the revised job description was accepted as the final job description for a CAD/CAM technician in this research. No further job descriptions were mailed for evaluation.

Findings for Research Question 2

Research Question 2: With emphasis given to the CAD/CAM hardware and software and attention to the industrial applications of the system, what are the duties and tasks performed by CAD/CAM technicians operating these systems?

The researcher addressed the second research question by following 12 steps. These procedures included examining existing materials to develop a duty and task list and verifying that list by interviewing 36 CAD/CAM technicians in southern Michigan. The findings for each of the 12 steps are discussed below.

1. Reviewing operating manuals of CAD/CAM systems to develop appropriate duty and task listings. Three operating manuals of CAD/CAM systems were reviewed (Finite Element Modeling Reference Manual: Mechanical Design [Computervision, 1983]; Numerical Control (NC) Reference Manual [Computervision, 1982]; and Inside AutoCAD [Raker, 1985]). Information from these manuals was difficult to use in developing original task listings but was helpful in verifying existing task listings.

2. Reviewing duty and task statements from existing occupational analyses. The researcher reviewed existing occupational-analysis data in the field of CAD, CAM, or CAD/CAM and found three duty and task lists.

The first duty and task list is in the field of CAD and was developed by Abram and Ashley (1983). It includes the following items:

1. Operate System
   Boot system/start up procedure
   Log in/on terminal
   Load start file
   Execute drawing assignment
   Manage files
   Plot out drawings
   Store a file
   Shut down a system
   Log off/out

2. Execute Drawing Assignment
   A. Change Existing Drawings or Details
      Plan drawing changes
      Find drawing file
      Load drawing file

Execute changes
Obtain approval/check drawing changes
Plot out drawing
Update file

B. Document Original Designs
Plan drawing layout
Load start file
Execute detailed drawings
Obtain approvals
Plot out drawing
Store files

C. Execute/Change Detailed Drawings
Set up drawing format
Create drawing components
Confer with designer/engineer
Compose drawings

3. <u>Compose Drawings</u>
Understand and use system commands
Create and manipulate geometry
Select geometry
Add text
Rotate views
Move views
Scale views
Dimension a drawing (p. 10)

The following CAM duty list was also developed by Abram and Ashley (1983):

1. Analyze part geometry, materials, finish, and precision required.

2. Select machine types and tooling required.

3. Design and select hold-down jigs and fixtures.

4. Use a programming language to define finished part geometry and the geometry of the raw casting, bar stock, or other material. . . .

5. Determine tool path (feed rates, spindle speed, and tool selection) for most efficient use of a machine tool. . . .

6. Verify work against graphic representation on hard copy or CRT plotting devices.

7. Edit source program to correct errors or refine process.

8. Run post processes standardized file output to obtain machine image code in either punched tape or direct NC data file format.

9. Test run program in "dry run" mode. . . .

10. Machine prototype on a NC tool. . . .

11. Release program for production. . . . (pp. 22-23)

The following list of duties for a NC/CNC programmer was developed by the Ministry of Colleges and Universities (1982) in Ontario, Canada:

1. Determine manufacturing method.
2. Generate manual part programs.
3. Generate computer-assisted part program.
4. Supervise program and tool proving.
5. Create and maintain files and records.
6. Trouble-shoot NC-related problems
7. Research and implement new technology.
8. Generate part program using CAD/CAM system.

3. <u>Reviewing textbooks in the field of CAD/CAM to develop duty and task statements</u>. Four textbooks in the field of CAD/CAM were reviewed: <u>Flexible Automation</u> (Kief, 1985), <u>The CAD/CAM Handbook</u> (Machover & Blauth, 1980), <u>CAD/CAM Handbook</u> (Tiecholz, 1985), and <u>Introduction to CAD</u> (Vosinet, 1985). Tiecholz's book, <u>CAD/CAM Handbook</u>, was the only book of the four reviewed that contained any duty and task statement listings. Teicholz's duty and task listing is as follows:

1. Systems Start-up and Shut-down
    a. System power up and initial boot up. . . .
    b. Regular log-in procedure
    c. Crash recovery procedures
    d. Nightly shutdown of all systems

2. Part Naming Convention
    a. Coping and moving a part
    b. Multiple sheet drawings
    c. Part construction phase
    d. Checking phase
    e. Revision phase
    f. Release phase
    g. Experimental phase
    h. Production phase

3. Drawing Conventions and Techniques
    a. Developing a construction strategy. . . .
    b. Filling procedures
    c. Units and scale
    d. Layering. . . .
    e. Saving and restoring display images. . . .
    f. Formats. . . .
    g. Geometric construction
    h. Layout and construction techniques. . . .
    i. Detail construction techniques. . . .
    j. Assembly-drawing techniques. . . .
    k. Sectioning. . . .
    l. Dimensioning. . . .
    m. Decals, charts, notes, symbols, geometry
    n. Plotting. . . .

4. Drawing Route Flowchart

5. Location of Most Current Version of a Part
    a. Search over network architecture
    b. Search of all system nodes
    c. Search of archival files

6. Engineering Change Procedure

7. Operator Responsibility
    a. Maintenance
    b. Meetings

8. Forms

9. Database Maintenance
    a. Check data base
    b. Pack data base
    c. Sorting the data base
    d. Regenerate graphics
    e. Dealing with problem part. . . . (pp. 8.18-8.21)

4. Developing duty statements from the researched materials. The researcher reviewed information derived from the review of literature and developed 12 duty statements, which were reviewed by four college instructional staff and two incumbent workers. The 12 duties are as follows:

1. Manipulate mechanical drawing information.
2. Generate electronic circuit designs.
3. Generate part programs.
4. Perform data base maintenance.
5. Build component libraries.
6. Interpret engineering and technical data.
7. Compute engineering and technical data.
8. Communicate engineering and technical data.
9. Perform system start-up and shut down activities.
10. Perform design activities.
11. Perform engineering functions.
12. Interpret or create computer software programs.

5. Prepare task listing for each duty. Using the information gathered in the literature search, the researcher developed 155 task statements.

6. Organizing the duty and task statements into a preliminary inventory. The researcher organized the duties and tasks into a preliminary inventory.

7. Pilot testing the inventory. The same four college instructional staff and two incumbent workers who had reviewed the 12 duty statements reviewed the 155 tasks contained in the preliminary inventory.

8. Revising the inventory based on information received during the interviews. Based on the review of the six professional people, the researcher revised the inventory to include 159 tasks. (See Appendix D.)

9. Developing an interview schedule. A four-section interview schedule was developed for verifying the duty and task lists. The first section was a letter of introduction for the technicians, and the second was a consent form. The third section included a series of general questions for the CAD/CAM technicians. The fourth section was a task-analysis check sheet. (See Appendices E and F for this instrument.)

10. Selecting a sample of CAD/CAM technicians. A stratified sample was drawn from the population of CAD/CAM technicians. The sample of technicians and supervisors was selected from a target population consisting of technicians who operated common CAD/CAM systems in a variety of industrial applications.

The sample consisted of CAD/CAM technicians who operated or supervised technicians who operated the following CAD/CAM systems:

IBM 25% (11% IBM CADAM and 14% GM Corporate Graphics System--CGS), Computervision 17%, Prime 14%, Intergraph 6%, and eight other systems constituting the remaining 41% of the sample.

To reflect the dominance of the use of CAD/CAM systems in the automotive industry, technicians and supervisors from the automotive industry accounted for 58% (21 participants) of the sample, whereas those from the nonautomotive application made up the other 42% (15 participants) of the sample. (See Table 4.2.)

Table 4.2.--Sample of CAD/CAM technicians, by system and application.

System	Automotive	Nonautomotive
IBM/CADAM	3	1
IBM/GM Corp. Graphics CGS	5	0
Computervision	5	1
Prime	1	4
Intergraph	2	0
Applicon	0	2
Calma	0	2
CIMLINC	2	0
Data General	1	0
DEC/McAuto	0	2
DEC/CAMAX	0	1
Gerber	1	1
Graftek	1	1
Total	21	15

Most technicians interviewed were identified by salesmen of CAD/CAM systems. Most of the salesmen were willing to give several names of companies and contact people. A CAD instructor from Macomb Community College provided several names of companies and contact people in the Detroit area, and a CAD instructor from Lansing Community College provided several names of IBM users in the Lansing area. (Lansing Community College serves as the regional training center for IBM.)

11. Verifying the inventory by interviewing incumbent CAD/CAM technicians and supervisors with six months or more experience. The interviewees were 36 technicians and supervisors who were operating or supervising the operation of CAD/CAM systems. These individuals represented 24 different companies, running 12 different types of CAD/CAM systems. (See Appendix G.)

Sequential sampling was used to determine the sample size (Fox, 1969). The data from two sets of 18 questionnaires each were tabulated and compared. The first set had 107 tasks (67% of the total tasks) meeting the 50% performance criterion, whereas the second set and the final list showed 105 tasks (66% of the total tasks) meeting the 50% performance criterion. The same 105 tasks were identified in both surveys. The researcher determined that there was no meaningful divergence between the two samples, so additional data would not provide new insights into the study. Thus, the final sample size was maintained at 36 persons. (See Appendix G.)

Twelve of the interviewees were technicians/operators, and 27 were supervisors or managers. All but one of the supervisors/managers also served as a CAD/CAM system operator. The researcher interviewed all 36 CAD/CAM technicians at their places of employment. Eleven of the 36 technicians interviewed chose to remain anonymous.

Responses to questions concerning name, company, phone, CAD/CAM system and software, and system application are reported in Appendix G. All of the CAD/CAM technicians interviewed had six months or more work experience. Table 4.3 contains additional work-experience information.

Table 4.3.--Work and supervisory experience of all CAD/CAM technicians interviewed.

Years of Experience	Number of Technicians Responding
<u>As a CAD/CAM Technician</u>	
6 months to 1 year	2
1 to 2 years	3
2 to 3 years	6
3 to 4 years	7
4 to 5 years	5
5 to 6 years	0
Over 6 years	13
<u>As a Supervisor of CAD/CAM Technicians</u>	
6 months to 1 year	3
1 to 2 years	5
2 to 3 years	4
3 to 4 years	5
4 to 5 years	4
5 to 6 years	1
Over 6 years	5

In Section 3 of the interview, technicians were asked, "Do you feel generic CAD/CAM machine/software training is sufficient for job entry?" All 36 technicians answered affirmatively. They all felt that the type of hardware and/or software a person learned on did not make much difference because all systems operate basically the same. Part of the command structure varies on different types of systems, but these commands can easily be learned, according to the technicians interviewed.

The fourth section of the interview was a check sheet on which the 12 duties and 159 task statements were listed. (See Appendix F.) All 36 CAD/CAM technicians completed these check sheets during the on-site interview. Tabulations of the data collected from the task check sheets are contained in Appendix H.

12. Illustrating and analyzing the data by developing five tables.

A. A table showing the responses of the CAD/CAM technicians to the question, "Do you perform this task?" is contained in Appendix H. In this table, responses of CAD/CAM technicians who were using their equipment for applications in the automotive industry and those who were using their systems for nonautomotive applications are compared.

B. A table listing the tasks that met the established 50% performance criterion is contained in Appendix I. Of the initial 12 duty statements and the 159 task statements, 9 duties and 105 tasks met the 50% performance criterion. The duty statements not included in the final task list are shown in Figure 4.1. None of the tasks listed under the duties in Figure 4.1 was performed by 50% or more of the technicians. The 105 tasks that met the established criterion accounted for 66% of the total list. All of those tasks were performed by at least 50% of the technicians interviewed.

Duty B: Generate Electronic Circuit Designs
(Tasks B1, B2, B3, B4, B5, B6, B7, B8)

Duty K: Perform Engineering Functions
(Tasks K1, K2)

Duty L: Interpret or Create Computer Software Programs
(Tasks L1, L2, L3, L4, L5, L6, L7, L8)

Figure 4.1: Duties and tasks eliminated from the final task list.

Table 4.4 shows the number of tasks accepted under each duty statement.

C. A table in which tasks are ranked from highest to lowest number of yes responses, indicating respondents performed the task, is contained in Appendix J. This list shows that 14 tasks (13% of the total number) were performed by 100% of the technicians.

D. The results of the ANOVA revealed a significant overall difference between groups (F [8,96] = 6.15 < .0001). (See Table 4.5.) Individual t-tests were then performed to locate which groups contributed to the overall significance. The means, standard deviations, and t-tests for each group appear in Table 4.6.

Table 4.4.--Number and percentage of tasks accepted under each duty statement.

Duties		Tasks	
	No.	Total Reported	%
Duty A: Manipulate Mechanical Drawing Information	53	50	94
*Duty B: Generate Electronic Circuit Boards	8	0	0
Duty C: Generate Part Programs	22	15	58
Duty D: Perform Data Base Maintenance	16	14	87
Duty E: Build Component Libraries	3	1	33
Duty F: Interpret and Read Blueprints	5	5	100
Duty G: Compute Engineering and Technical Data	6	6	100
Duty H: Communicate Engineering and Technical Data	7	7	100
Duty I: Perform System Start-up and Shut-down Activities	6	4	66
Duty J: Perform Design Activities	23	3	13
*Duty K: Perform Engineering Functions	2	0	0
*Duty L: Interpret or Create Computer Software	8	0	0
Total	159	105	66

*Duties omitted from the final task listing.

Table 4.5.--Results of F-test (analysis of variance).

Duty	Mean	S.D.	N
Automotive			
A	82.10	17.88	50
C	72.06	9.50	15
D	71.97	16.47	14
E	66.67	.00	1
F	97.14	6.39	5
G	92.36	10.75	6
H	80.27	18.73	7
I	72.62	12.53	4
J	66.67	16.50	3
For entire sample	79.57	16.92	105
Nonautomotive			
A	85.73	16.88	50
C	48.00	13.62	15
D	76.19	20.38	14
E	86.67	.00	1
F	96.00	3.65	5
G	90.00	15.63	6
H	82.86	15.32	7
I	88.34	8.39	4
J	77.78	15.40	3
For entire sample	79.49	20.75	105

Table 4.6.--Individual t-tests for duty statements.

Duty	Number of Tasks	t-Test
A	50	t = 1.52, 49, p < .134
C	15	t = 6.51, 14, p < .000
D	14	t = .87, 13, p < .401
E	1	t = 99.00, 0, p < .990
F	5	t = .43, 4, p < .688
G	6	t = .34, 5, p < .749
H	7	t = .53, 6, p < .617
I	4	t = 6.88, 3, p < .006
J	3	t = 17.55, 2, p < .003

As indicated by the t-test, the tasks in Duty C (Generate part programs), Duty E (Build component libraries), Duty I (Perform system start-up and shut-down activities), and Duty J (Perform design activities) were performed at a significantly different rate between the automotive and nonautomotive groups. The reader should note, however, that the sample size for Duties I and J was very small, so these results may not be reliable.

Findings for Research Question 3

> Research Question 3: What tasks are most frequently performed by a CAD/CAM technician, and which tasks are the most important for a technician to be able to perform at job entry?

The third research question was answered by compiling the data collected into the following tables.

1. A table listing the frequency with which each task was performed. The frequency with which each task was performed is presented in Appendix K. The duties and tasks are listed, as are the total number of technicians performing each task, frequency of performance (daily, weekly, monthly, and less than monthly), the percentage of responses in each category, and the mean response score.

2. A table listing the importance of each task. The importance of each task to job entry is shown in Appendix L. This table lists the duties and tasks, the total number of technicians performing each task, and the number of technicians giving each importance rating (essential, very desirable, desirable, unnecessary, not sure). The

percentage of responses in each category and the mean response score are also given.

3. Two tables ranking the tasks. Appendixes M and N contain rank orderings of the tasks that met the 50% performance criterion established for this research. In Appendix M, the tasks are ranked from highest to lowest mean importance score. A review of the data indicated that all 105 tasks were given a rating above 1.5 (desirable), and all but one task had a frequency score above 2.5 (weekly). Task E1 had a frequency rating of 2.41, but since it was performed by over 50% of the technicians and it was given a desirable (desirable for job entry) rating, this task was included in the final task listing.

Nineteen tasks were rated between 3.5 and 4.0 (essential to job entry). (See Table 4.7.) As shown in Table 4.7 and Appendix M, all five of the tasks under Duty F (Interpret and read blueprints) were considered essential to job entry. Sixty tasks were reported as being performed daily.

Ten tasks under Duty A (Manipulate mechanical drawing information) were rated essential to job entry. These basic skills included creating points, creating lines perpendicular, creating lines by using the absolute coordinate system, creating lines parallel, inserting text, creating circles using the keyboard, editing geometry, zooming in or out on a drawing, deleting entities, and editing text.

Table 4.7.--Tasks rated essential for job entry.

	Task Statement	Mean Score
F1	Interpret basic views in a working drawing	3.81
A8	Create points	3.69
A14	Create lines perpendicular	3.69
F2	Interpret basic dimensions of a working drawing	3.69
A10	Create lines by using the absolute coordinate system	3.67
A13	Create lines parallel	3.67
A22	Insert text	3.63
A16	Create circles by keyboard input	3.61
A20	Edit existing geometry	3.58
C14	Input machining parameters	3.57
F3	Interpret tolerance dimensions on a working drawing	3.57
F5	Interpret geometric tolerance symbols	3.57
A21	Zoom in or out on a drawing	3.56
G2	Apply principles of plane geometry	3.56
H3	Give and receive instructions verbally	3.54
A29	Delete existing entities	3.53
J16	Measure an existing part to generate dimensions	3.53
A23	Edit text	3.51
F4	Calculate basic dimensions where tolerancing is not bilateral	3.50

Four other tasks, representing four different duties, were rated essential. These three duties and tasks were: Duty C (Generate part program), C11 Input machining parameters; Duty G (Compute engineering and technical data) Apply principles of plane geometry; Duty J (Perform design activities), J16 Measure an existing part to generate dimensions; and Duty H3 (Communicate Engineering and Technical Data) Give and receive instructions verbally.

In Appendix N, the tasks are ranked from highest to lowest frequency of performance. Sixty tasks (57%) received a score of 3.5 to 4.0 (daily). Eighteen of the 19 tasks that were rated essential were also rated as daily tasks. Task J16 was rated 3.53 (essential) and 3.26 (weekly).

Calculating the correlation between the frequency of performance of the tasks and their level of importance. The data collected on the importance of each task to job entry and the frequency with which each task was performed indicated that there was a moderate to strong positive correlation between the two. The mean values of each of the 105 tasks were compared using Pearson's product-moment correlation coefficient (Pearson's r) (Walpole, 1974). The statistical analysis using Pearson's formula resulted in an r-value of .75 (between moderate and strong positive correlation). This correlation indicated that as the importance of the task increased so did the frequency with which it was performed (at the .99% confidence level). These findings were also supported by the tables in which the tasks were ranked. As shown in the tables, of the 19 tasks rated essential for job entry, 18 were rated as being performed daily. (See Appendices M and N.)

Findings for Research Question 4

Research Question 4: What program-development models can be identified for using the products of this occupational analysis?

The fourth research question was answered in Chapter II, in which five strategies or models for using occupational-analysis data to develop vocational or technical programs were examined. A comparison of the five models for use as a program-development model was also presented.

Summary

A functional job definition for a CAD/CAM technician was established by means of a jury technique. A final list of 9 duties and 105 tasks for CAD/CAM technicians was also compiled. Nineteen tasks had a rating of 3.5 to 4.0 (essential to job entry). Sixty tasks were also rated 3.5 to 4.0 (performed daily).

Tables included in Appendices H through N contain the data collected on each duty and task statement. Using Pearson's product-moment correlation coefficient, it was found that there was a strong positive correlation between frequency with which the CAD/CAM technicians performed a task and the importance of that task to job entry.

CHAPTER V

SUMMARY, CONCLUSIONS, RECOMMENDATIONS, IMPLICATIONS FOR FURTHER RESEARCH, AND REFLECTIONS

This chapter contains a summary of the study, conclusions drawn from the study findings, recommendations, implications for further research, and reflections by the researcher.

Summary

The specific problem of this study was to identify the competencies necessary to perform the job of CAD/CAM technician. The researcher had five objectives in conducting this study:

1. To provide a functional definition of the emerging occupation of CAD/CAM technician.

2. To identify and list the duties and tasks performed by CAD/CAM technicians. Emphasis was given to the CAD/CAM hardware and software, but attention also was given to industrial applications of the CAD/CAM system.

3. To identify the frequency with which each task is performed and to determine the relative importance of each task for job entry.

4. To identify program-development models for using the products of an occupational analysis.

5. To provide a program-development model and guidelines for using the products of this occupational analysis to develop programs to train CAD/CAM technicians.

The first four objectives were addressed by means of four research questions. Findings were presented in Chapters II and IV. The fifth objective was addressed through a review of the literature and the development of a program-development model. Findings are reported and developed as recommendations in this chapter.

The first research question (What is a functional definition of the occupation of CAD/CAM technician?) was answered by using a jury technique to verify a job description for CAD/CAM technician.

The second research question (With emphasis given to the CAD/CAM hardware and software and attention to the industrial applications of the system, what are the duties and tasks performed by CAD/CAM technicians operating these systems?) was answered by interviewing 36 CAD/ CAM technicians in southern Michigan. The interviewees were given a check sheet on which to rate 12 duty statements and 159 task statements. The technicians were first asked, "Is the task performed?" Responses to this question showed that 9 duties and 105 tasks met the 50% performance criterion established by the researcher.

Research Question 3 (What tasks are most frequently performed by a CAD/CAM technician, and which tasks are the most important for a technician to be able to perform at job entry?) was also answered during the interviews. The 36 CAD/CAM technicians were asked to rate the tasks in terms of how frequently the tasks were performed and how important the task was to job entry. Of the 12 duties and 159 tasks, 9 duties and 105 tasks met the criterion of the research. Nineteen tasks were found to be essential for job entry. Sixty tasks were performed daily.

Research Question 4 (What program-development models can be identified for using the products of this occupational analysis?) was answered in Chapter II. Five strategies or models were outlined that could be used for developing vocational- or technical-education programs. In all five models, occupational-analysis data are used for instructional purposes. The five models were developed by Harold Resnick, Philip Teske, Robert Steely, The Center for Vocational Education at The Ohio State University, and Robert Mager and Ken Beach, Jr.

Conclusions

Objective 1

The first objective was to provide a functional definition of the emerging occupation of CAD/CAM technician. The definition developed in this research is as follows:

> A CAD/CAM technician is the person who operates a CAD computer terminal that transmits data to a CAM data base or machine tool. He/she is responsible for manipulating mechanical drawing information, generating part programming information, performing data base maintenance and is normally required to handle day-to-day administrative activities as:
>
> a. daily and weekly file management
> b. daily operation and maintenance of the printer and plotter
> c. administration of manufacturing procedures
> d. answering other (CAD, CNC, CAM) operator questions
> e. assisting in training other CAD/CAM technicians
> f. assisting in the design of new and existing products and/or manufacturing processes

Even though this definition was approved with a 4.28 mean rating (between good and excellent) by all seven technicians interviewed, it should be remembered that the job description may vary with the size of the company. The job description of a CAD/CAM technician in a large firm may be narrower than that in a smaller firm. Often, in large firms, systems people performed some of the data-base management functions, as well as system and plotter maintenance. They also may have their own training departments to train others. A small firm may employ only a few CAD/CAM technicians, so they would be responsible for many functions in their department.

Objective 2

The second objective was to identify and list the duties and tasks performed by CAD/CAM technicians. Emphasis was given to the CAD/CAM hardware and software, but attention also was given to industrial applications of the CAD/CAM system. The results of the interviews with 36 CAD/CAM technicians verified that 9 duties and 105 tasks of the initial 12 duties and 159 tasks were performed by at least 50% of the technicians. These tasks are listed by duty area in Appendix I. The tasks are ranked from highest to lowest mean percentage score in Appendix J.

All of the technicians interviewed had more than six months work experience; 13 (36%) had more than six years work experience as a CAD/CAM technician. Twenty-seven of the technicians interviewed also had six months or more experience as a supervisor of CAD/CAM technicians. Only one supervisor did not currently operate a CAD/CAM system as part of his assignment. The researcher concluded that the technicians interviewed had an excellent understanding of the field of CAD/CAM and that almost all supervisors also operated systems regularly as part of their normal work assignment.

The technicians were also asked, "Do you feel generic CAD/CAM system training is sufficient for job entry?" All 36 technicians said that training on generic CAD/CAM machine/software was sufficient for job entry. Some technicians, however, stated that the command structure differs among systems, but these commands can easily be learned once one knows how to operate a system. A conclusion relating to equipment is that a training program could use any type of CAD/CAM equipment to teach the basic job-entry CAD/CAM skills; however, teaching on the system a person is going to operate on the job would be best.

The results of the ANOVA revealed a significant difference between the automotive and nonautomotive groups. Individual t-tests indicated four duties--Duty C (Generate part programs), Duty E (Build component library), Duty I (Perform system start-up and shut-down activities), and Duty J (Perform design activities)--were performed at a significantly different rate between the automotive and nonautomotive groups. The remaining five duties were performed at the same rate. These duties included Duty A (Manipulate mechanical drawing information), Duty D (Perform data base maintenance), Duty F (Interpret and read blueprints), Duty G (Compute engineering and technical data), and Duty H (Communicate engineering and technical data). The researcher concluded that learning the task competencies for each duty would be of equal value for both groups surveyed. These findings indicate that a training program for technicians in either the automotive or nonautomotive industry should include teaching the same tasks under the abovementioned duty areas.

These data show that the majority of the task statements (82) were performed at the same rate, while 23 tasks were performed at a different rate. Also, one must note that the sample size of Duties E, I, and J was very small, so the information may not be reliable.

The researcher cautions against excluding tasks just because they are currently not performed. This lack of performance may result from the fact that the CAD/CAM systems are still very new for most industries; they are not being used to the fullest extent, nor are technicians trained sufficiently to take advantage of all the capabilities of these systems. Duty C (Generate part programs), for example, is the heart of the CAM portion of CAD/CAM, and if this is excluded from a training program, one may only receive CAD training.

Under Duty E (Build component library), Task E1 (Create library manually as required) was performed by 66.67% of the automotive group, whereas 86.67% of the nonautomotive group performed this task. Because more than 66% of both groups performed the task, it should be included in instructional programs for either group.

Duty F (Perform start-up and shut-down activities) may be controlled by other factors than automotive or nonautomotive applications. The biggest factor may be whether a company has a service technician who operates and maintains systems. If so, the

CAD/CAM technician is not apt to perform this task. Because of the small sample size (3) for Duty J (Perform design activities), the researcher suggests that the user of the information conduct a local study of this duty to check for local needs.

Fifty-four tasks were eliminated from the research because they were not performed by 50% of more of the CAD/CAM technicians interviewed. These tasks should be examined for use in special programs. Certain industries might need people who have been trained in these competencies.

Objective 3

The third objective was to identify the frequency which which each task is performed and to determine the relative importance of each task for job entry. Four tables were constructed to display the frequency of performance and importance for job entry of each task. (See Appendices K, L, M, and N.) Appendix K illustrates the mean frequency score and percentage of responses for each task. Appendix L shows the mean importance for job entry score and the percentage of responses for each task.

Appendix M contains a ranking of the tasks from highest to lowest mean importance score. In this table, 19 tasks are identified as essential to job entry. These tasks should be included in any basic training program for entry-level CAD/CAM technicians.

Appendix N displays a ranking of tasks by mean frequency of performance score. Sixty tasks were rated as being performed daily. Eighteen of the 19 tasks that were rated essential were also rated as being performed daily. The fact that the tasks were performed daily would indicate they should be included in a basic training program. The other tasks that were performed daily should also be considered for inclusion in a basic training program. A problem with the frequency of performance ratings in this study is that most people who participated in the research were experienced and were performing tasks that a beginning worker might not perform when first hired.

A high positive correlation was found between the importance of a task for job entry and the frequency with which the task was performed. The r-value for the 105 tasks was calculated at .75 (a moderate to strong correlation, according to Pearson's product-moment correlation coefficient). In considering additional tasks in this field, one can be confident that if a task is performed frequently it is important for job entry.

Objective 4

The fourth objective was to identify program-development models for using the products of an occupational analysis. Five strategies or models were outlined in Chapter II that could be used for developing vocational- or technical-education programs. In all five models, occupational-analysis data are used for instructional purposes.

Any of the models reviewed in Chapter II could be used to develop vocational- or technical-education programs. Some of the models have advantages over others for program development. A sixth model was developed as part of this study and is presented in the following section. This model is a hybrid of the five models discussed in Chapter II.

Objective 5

The fifth objective (To provide guidelines and examples for using the products of this occupational analysis for program development needed to train CAD/CAM technicians) was met through the development of a program model, illustrated in Figure 5.1, and guidelines for this model.

Define the occupation. Define the occupation of CAD/CAM technician and develop a job description (review the job description outlined in this study). Work with an area-wide advisory committee to define the job in the service area.

Conduct an occupational analysis. Examine the occupational analysis to document the skills and knowledge required to fulfill the requirements of that occupation. This process is done by collecting duty and task statements through a literature search and interviews with professionals from the field. The tasks should be clustered by duty area. The Develop A CUrriculuM (DACUM) technique can be used to obtain duty and task listings. Verify the task listing using a formal questionnaire or by working with a local advisory committee.

Analyze the data by first eliminating those tasks that are not performed by at least 50% of the interviewees (a higher or lower percentage can be used). A second criterion used to analyze the tasks is based on the importance of each task for job entry and the frequency with which a task if performed. A third way to analyze the data is to rank the tasks, with the tasks having the highest mean importance (for job entry) score first and the lowest last. This step will identify those tasks that are essential for job entry.

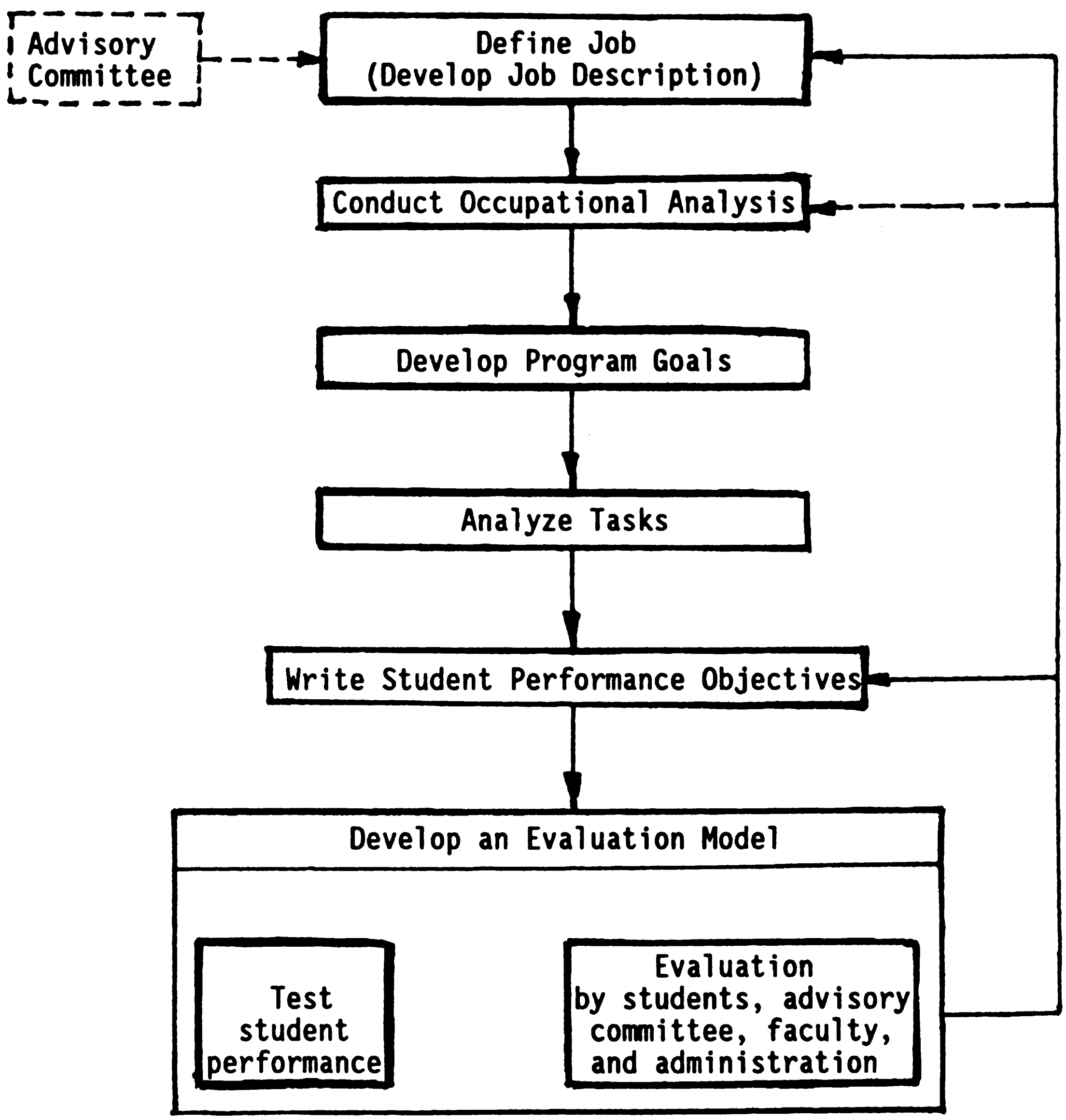

Figure 5.1: Program-development model.

Once the tasks have been identified, a final clustering of the tasks should be performed. The common tasks should be clustered in their duty area. Next, the tasks should be sequenced from simple tasks to complex principles, from basic tasks to complex tasks.

Develop program goals. Once the duties and tasks an individual must perform to be successful in the field of CAD/CAM in a given service area are identified and verified, the parameters of the educational program itself have been established. The program developer now has the tasks delineated which must be included in the instructional program. At this point the program goals can be written. Program goals are broad, student-oriented action statements that identify the knowledge, skills, and attitudes a student will demonstrate upon completion of an instructional program.

Analyze tasks. First, the tasks verified in the occupational analysis need to be analyzed to determine the learning domain (psychomotor, cognitive, affective). Second, each task should be analyzed to determine enabling objectives, which become the basis for the instructional content of the course(s).

Write student performance objectives. Write student performance objectives for each task area (statements of instructional intent that describe in advance the performance a student will demonstrate upon completion of a learning experience).

Structure courses. After the performance objectives have been written, develop course outlines. A course is a major unit of a program that covers specific performance objectives or practices related to a given discipline or occupation. A course outline should be written in a uniform manner, sequencing the performance objectives and units of instruction in the most logical order.

When developing a course, one must also determine instructional strategies for teaching each performance objective (the methods used for delivery of instruction, as well as facilities, equipment, instructional materials, and teaching aids). Objective-referenced tests for each performance objective (tests that reference and use as their basis a stated performance objective) need to be written.

Develop a program-evaluation model. A program-evaluation model should be developed so administrators, staff, advisory committee members, and students can evaluate the program. Program evaluation is a process through which information is collected and analyzed for purposes of program improvement. The evaluation occurs after program implementation. Program evaluation calls for the development of a method to keep the program up to date and on target.

Administrators, staff, and advisory committee members can evaluate the program based on student performance; job placement; student satisfaction; employer satisfaction; condition of tools, equipment, and facilities; and staff performance and satisfaction, and other factors. The occupation itself needs to be re-evaluated on a regular basis to make sure the proper tasks are being taught and the goals of the program are meeting the needs of the community. Program revisions can be made, based on the findings of these evaluations.

Student performance can be used to evaluate the program. If students are not performing tasks at the desired level in class or on the job, one may have to restructure the performance objectives to increase desired performance. Course outlines and lesson plans may have to be changed to include improved learning strategies to better meet students' needs.

Recommendations

The following recommendations are made for the training of CAD/CAM technicians and the use of these occupational-analysis data for instructional purposes in a vocational- or technical-education program.

1. All job-entry-level CAD/CAM training should include the tasks found under Duty F (Interpret and read blueprints):

F1: Interpret basic views in a working drawing.
F2: Interpret basic dimensions of a working drawing.
F3: Interpret toleranced dimensions on a working drawing.
F4: Calculate basic dimensions where tolerancing is not bilateral
F5: Interpret geometrical tolerance symbols

2. All job-entry-level CAD/CAM training should include the following tasks under Duty A (Manipulate mechanical drawing information):

A8: Create points
A10: Create lines by using the absolute coordinate system
A13: Create lines parallel
A14: Create lines perpendicular
A16: Create circles by keyboard input
A20: Edit existing geometry
A21: Zoom in or out on a drawing
A22: Insert text
A23: Edit text
A29: Delete existing entities

To determine which additional tasks from this duty area should be included, the local service area can be surveyed using a local advisory committee.

3. All CAD/CAM training should include the following tasks under Duty C (Generate part program), Duty G (Compute engineering and technical data), Duty H (Communicate engineering and technical data), and Duty J (Perform design activities):

C11: Input machining parameters
G2: Apply principles of plane geometry
H3: Give and receive instruction verbally
J16: Measure an existing part to generate dimensions

To determine which additional tasks form these duty areas, the local service area can be surveyed using a local advisory committee.

4. The duties and tasks in this research should be updated regularly.

5. Use a CAD/CAM system that best meets the needs of a service area. Work with a local advisory committee to select a system. Any CAD/CAM system can be used to teach basic job-entry-level skills.

6. When developing a CAD/CAM program, one should work with the local service area to review the training needs. A difference in training needs seems to exist between the automotive and nonautomotive industries.

7. A program-development model using occupational analysis for instructional purposes should be used in developing vocational- and technical-education programs. Such a program model should include the following: (a) Job Description, (b) Occupational Analysis, (c)

Program Goals, (d) Analysis of Tasks, (e) Performance Objectives, (f) Course Development, and (g) Program Evaluation.

8. The findings of this research also can be used for developing inservice programs for training technicians working in the field as CAD or CAM operators, draftsmen, and the like, who want to become CAD/CAM technicians.

Implications for Further Research

Because of the rapidly changing technology of CAD/CAM, additional research should be conducted annually to determine what duties and tasks are still being used and what new ones have been introduced. In this research, 12 duties and 159 tasks were evaluated. It was found that 9 duties and 105 tasks were being performed by at least 50% of the study participants. Such areas as Duty J (Perform design activities) and Duty C (Generate part programs) may expand and include more tasks as companies increase the use of CAD/CAM. Such areas as Duty B (Generate electronic circuit boards) and Duty K (Perform engineering functions), which were not used by 50% of the technicians at the time of the study, could gain additional users in the future. The tasks under Duty K (Perform engineering functions--K1 (Use finite element modeling for structural analysis) and K2 (Use mechanics/kinematics to determine movements with the work area)--are new to the CAD/CAM field and are likely to gain popularity as technicians learn the applications of this software. Task K2 should increase in popularity as robotics is further integrated into the manufacturing environment.

Further research should enhance the understanding of the occupation of CAD/CAM technician and provide additional information to be used in improving instruction of future CAD/CAM technicians.

Reflections

The research findings indicated that a large number of common duties and tasks can be taught to people pursuing the occupation of CAD/CAM technician, no matter what the industrial application. This finding supports the belief that educational institutions can offer "generic" CAD/CAM training in preparing CAD/CAM technicians.

During the interviews with technicians, the researcher discovered that a majority of the CAD/CAM technicians in southern Michigan and their co-workers had associate degrees. Some of the other CAD/CAM technicians interviewed had been trained as part of an apprenticeship program, whereas others had engineering degrees. This finding indicates that community colleges should continue to develop associate degree programs in the field of CAD/CAM.

The job title CAD/CAM technician is not common in the industry. Even though a number of people perform the duties of a CAD/CAM technician, they are not all called by that title. Many of these CAD/CAM jobs have evolved over time, and although the duties of the job now include integrated CAD/CAM, the job title or classification has not officially been changed.

Confusion still exists about the term "CAD/CAM," even within the industrial community. Some people refer to CAD/CAM as a process, yet they really are referring to either CAD or CAM separately.

Numerous CAD/CAM systems are being used throughout Michigan, and many new systems currently are being installed. The use of CAD/CAM will continue to increase over the next several years. Thus the need for trained CAD/CAM technicians will also grow.

Many CAD/CAM systems are installed in firms that are using only the CAD function of the machine. This was especially true of the Intergraph systems installed in southern Michigan. Also, some CAD/CAM systems are being used only for a CAM function. The researcher believes this situation will change, and companies will start to use these systems for the integration of CAD/CAM. Technicians will learn how to operate the equipment and how to use it in their industry. A good CAD/CAM training program, as outlined in this research, can facilitate this process.

APPENDICES

APPENDIX A

FIRST JOB DESCRIPTION QUESTIONNAIRE

APPENDIX A

FIRST JOB DESCRIPTION QUESTIONNAIRE

Job Description For A CAD/CAM Technician

The person who operates a CAD computer terminal that transmits data to a CAM data base or machine tool. A CAD/CAM technician is responsible for manipulating mechanical drawing information, generating part-programming information, performing date base maintenance and is normally required to handle day-to-day administrative activities as:

a. Daily and weekly file management.

b. Daily operation and maintenance of the printer and plotter.

c. Administration of manufacturing procedures.

d. Answering other (CAD, CNC, CAM) operators' questions.

e. Assist in training other CAD/CAM technicians.

*After your have read the above job description, please make any modifications to this description in the space provided below.

Sentence # 1

The person who operates a CAD computer terminal

that transmits data to a CAM data base or machine

tool.

Sentence # 2

A CAD/CAM technician is responsible for

manipulating mechanical drawing information,

generating part-programming information, performing

data base maintenance and is normally required to handle day-to-day administration activities as:

a. Daily and weekly file management

b. Operation and maintenance of plotter

c. Administration of manufacturing procedures.

d. Answering other (CAD, CNC, CAM) operators'

e. Assist in training other CAD/CAM technicians.

f.

* Make any additions to the job description of administration activities as you see fit.

Your name:____

Your company name: ______________________________

Your Position: __________________________________

Your CAD/CAM
system (hardware/software)_______________________

The industrial application
of your system: _________________________________

Please return this questionnaire in the enclosed envelope.

THANK YOU FOR YOUR COOPERATION

Don Boyer

APPENDIX B

SEVEN CAD/CAM EXPERTS WHO RESPONDED TO THE JOB DESCRIPTION SURVEY

APPENDIX B

SEVEN CAD/CAM EXPERTS WHO RESPONDED TO THE JOB DESCRIPTION SURVEY

1. Czerneak, Norm
   Section Manager
   Lear Siegler Instrument and Avionics Division
   Grand Rapids MI.
   616-241-8949

2. Freeman, Dan
   President
   CIM Tech Inc.
   Ada MI.
   616-676-9485

3. Hart, Robert
   Manager CNC Systems
   Autodie Corp.
   Grand Rapids MI.
   616-454-9361

4. Jonkers, Dave
   Supervisor of Tool and Die CAM
   General Motors Metal Plant CPC
   Wyoming MI.
   616-247-5595

5. Kadzban, Mark
   CAD Supervisor
   Quality Die and Mold
   Grand Rapids MI.
   616-531-3500

6. Luzenski, Dave
   CAD/CAM Operator & Night Supervisor
   Frost Inc.
   Grand Rapids MI.
   453-7781

7. Tindle, Randy
   Manager CAD/CAM Operations
   Frost Inc.
   Grand Rapids MI.
   453-7781

APPENDIX C

FINAL JOB DESCRIPTION SURVEY

APPENDIX C

FINAL JOB DESCRIPTION SURVEY

JOB DESCRIPTION: CAD/CAM TECHNICIAN

A person who operates a CAD (Computer Aided Design) computer terminal to create, edit, then transfer engineering data to a CAM (Computer Aided Manufacturing) data base or machine tool. A CAD/CAM technician is responsible for analyzing part drawing data, sketches, and design data. CAD/CAM technicians also generate part program information, perform data base maintenance, and are normally required to handle day to day administration activities as:

a. Daily and weekly file management.

b. Operation and maintenance of plotter, pens and terminals.

c. Answer other (CAD, CNC, and CAM) operators' questions.

d. Administration of manufacturing procedures.

e. Assist in training other CAD/CAM technicians.

f. Assist in the design of new and existing products and or manufacturing processes.

*After you have read the above job description please rate the description on the scale provided below.

(5) Excellent job description

(4) Good job description

(3) Acceptable job description

(2) Below average job description (needs changes)

(1) Not acceptable

Your name ______________________

Your position ____________________

Your company ______________________

Thank you for your cooperation.

APPENDIX D

INITIAL DUTY AND TASK LIST

APPENDIX D

DUTY AND TASK LISTING

(12 DUTY STATEMENTS)
(159 TASK STATEMENTS)

DUTY A: Manipulate Mechanical Drawing Information

A1. Set-up and take-down command menu.
A2. Set-up and take-down library menu.
A3. Modify a grid.
A4. Generate a 2D multiview drawing of a part using a function/alphanumeric key board.
A5. Generate a 2D multiview drawing of a part using a graphics tablet.
A6. Generate a 2D multiview drawing of a part using a light pen.
A7. Generate a 2D multiview drawing of a part using a joystick or mouse.
A8. Create points.
A9. Create lines by digitizing.
A10. Create lines by using the absolute coordinate system (Hor. Dis. X, Ver. Dis. Y)
A11. Create lines by using the incremental coordinate system.
A12. Create lines by using the polar Coordinate system.
A13. Create lines parallel.
A14. Create lines Perpendicular.
A15. Create circles by digitizing.
A16. Create circles by keyboard input.
A17. Create arcs by digitizing.
A18. Create arcs by keyboard input.
A19. Crate fillets.
A20. Edit existing geometry (points, lines, circles or arcs)
A21. Zoom in or out on a drawing.
A22. Insert text.
A23. Edit text.
A24. Insert library part symbols.
A25. Layer information in the system.
A26. Move existing entities.
A27. Rotate existing entities.
A28. Mirror existing entities.
A29. Delete existing entities.
A30. Copy existing entities.
A31. Generate a 3D pictorial drawing of a part.
A32. Generate cross-hatching for a section view automatically of a solid model.
A33. Generate cross-hatching for a section view manually.

A34. Create a single auxiliary view of a surface.
A35. Create multiple auxiliary views of an object.
A36. Create a ruled surface.
A37. Create a surface by rotation.
A38. Create a surface from a wire frame model.
A39. Blend two surfaces together (warped surfaces).
A40. Create splines or curved lines.
A41. Dimension a working drawing automatically.
A42. Place dimensions on a drawing one by one.
A43. Move existing dimensions.
A44. Delete dimensions.
A45. Place tolerances on size, location and angle dimensions.
A46. Place geometric tolerance symbols on shapes.
A47. Place true position tolerances on hole locations.
A48. Create bill of materials.
A49. Create an assembly drawing form existing part data.
A50. Print hard copy of data or drawing on a pen plotter.
A51. Print hard copy of data on a printer.
A52. Print hard copy of data on a electrostatic plotter.
A53. Check finish print for errors.

DUTY B: GENERATE ELECTRONIC CIRCUIT DESIGNS

B1. Design block diagrams.
B2. Design schematic diagrams.
B3. Run circuit emulation on CAD system.
B4. Manually (one by one) place components on a printed circuit board layout.
B5. Automatically place components on a printed circuit board layout.
B6. Generate a foil pattern of a printed circuit board via the CAD/CAM system.
B7. Check the design of the printed circuit board.
B8. Produce a database for manufacturing a printed circuit board to include:
   1. schematic drawing
   2. assembly drawing
   3. parts list
   4. circuit board detail drawing
   5. PC art work on board
   6. hole chart (drill drawing)

DUTY C: GENERATE PART PROGRAM

C1. Determine coordinate system to be used (absolute or incremental system).
C2. Generate or access part by using a part programming language based on task C1.

C3. Develop a work piece sequence of operations for one machine.
C4. Develop a work piece sequence of operations for multi-machines.
C5. Develop a work piece sequence of operations to include robotic applications.
C6. Develop a work piece sequence of operations for a total work-cell.
C7. Select machine tool to be used (drill).
C8. Select machine tool to be used (milling machine).
C9. Select machine tool to be used (lathe).
C10. Select machine tool to be used (grinder).
C11. Select machine tool to be used (EDM).
C12. Select tooling based on material being used.
C13. Select tooling based on finish desired.
C14. Input machining parameters (speeds, feeds, tool change information, etc.)
C15. Document the tooling and manufacturing process.
C16. Select/design work-holding fixtures.
C17. Generate computer tool paths.
C18. Invoke post processor or mainframe program.
C19. Perform tool path verification on CRT.
C20. Edit tool path motion.
C21. Generate output media (from printer or plotter).
C22. Delete and regenerate corrected tool path information for manufacturing.

DUTY D: PERFORM DATA BASE MAINTENANCE

D1. Remove files from disc.
D2. Reload files to disc.
D3. Create files.
D4. Edit files.
D5. Delete files.
D6. Move and copy files.
D7. Back-up files.
D8. Append files.
D9. Check data base.
D10. Pack data base.
D11. Sort data base.
D12. Create directories.
D13. Remove directories.
D14. Program a graphics menu file.
D15. Format blank diskette.
D16. Run and load a tape drive computer system.

DUTY E: BUILD COMPONENT LIBRARIES

E1. Create library manually as required.
E2. Create library automatically through a series of macro routines.
E3. Build a specific operation file for machining

(milling routines etc.).

DUTY F: INTERPRET AND READ BLUEPRINTS

F1. Interpret basic views in a working drawing.
F2. Interpret basic dimensions on a working drawing.
F3. Interpret toleranced dimensions on a working drawing.
F4. Calculate basic dimensions where tolerancing is not bilateral.
F5. Interpret geometrical tolerance symbols.

DUTY G: COMPUTE ENGINEERING AND TECHNICAL DATA

G1. Convert measurements from the English to the Metric system.
G2. Apply principles of plane geometry (constructions, parallel lines and planes, triangles etc.).
G3. Apply principles of descriptive geometry (intersections of lines, planes, solids, true size and shape, etc.).
G4. Apply principles of algebra (scientific notation, simultaneous equations, quadratic equations, etc.).
G5. Apply principles of trigonometry (solution of triangles using sines and cosines etc.).
G6. Apply principles of analytical geometry for compound angles and intersections etc.

DUTY H: COMMUNICATE ENGINEERING AND TECHNICAL DATA

H1. Read and interpret highly technical literature.
H2. Write technical reports and instructions.
H3. Give and receive instructions verbally.
H4. Give written instructions.
H5. Record and document necessary information.
H6. Sketch basic concepts.
H7. Generate specifications.

DUTY I: PERFORM SYSTEM START-UP AND SHUT-DOWN ACTIVITIES

I1. Power-up and initial boot-up of system.
I2. Log in on system.
I3. Perform crash recovery procedures.
I4. Shut-down system.
I5. Perform daily maintenance of the printer.
I6. Perform daily maintenance of the computer hardware.

DUTY J: PERFORM DESIGN ACTIVITIES

J1. Design stamping dies.
J1a. Read and interpret stamping die drawings.
J2. Design piercing dies.
J2a. Read and interpret piercing die drawings.
J3. Design blanking dies.
J3a. Read and interpret blanking die drawings.
J4. Design forming dies.
J5. Design progressive dies.
J5a. Read and interpret progressive dies drawings.
J6. Design plastic injection molds.
J6a. Read and interpret plastic injection mold drawings.
J7. Design vacuum molds.
J7a. Read and interpret vacuum mold drawings.
J8. Design blow molds.
J8a. Read and interpret blow mold drawings.
J9. Determine mold flow on the CAD/CAM system.
J10. Design jigs and fixtures.
J11. Produce product designs.
J12. Produce machine designs.
J13. Produce weldment drawings.
J14. Detail a designed part.
J15. Create modifications on a original designed part.
J16. Measure an existing part to generate dimensions, using metrology, for a drawing.

DUTY K: PERFORM ENGINEERING FUNCTIONS

K1. Use finite element modeling for structural analysis.
K2. Use mechanics/Kinematics to determine movements within a work area.

DUTY L: INTERPRET OR CREATE COMPUTER SOFTWARE PROGRAMS

L1. Interpret or create programs in BASIC language.
L2. Interpret or create programs in FORTRAN language.
L3. Interpret or create programs in PASCAL language.
L4. Interpret or create programs in "C" language.
L5. Interpret or create programs in APT language.
L6. Interpret or create programs in Compact II language.
L7. Interpret or create programs in other computer languages (__________________).
L8. Interpret or create manual NC part programs.

APPENDIX E

INTERVIEW COVER LETTER, CONSENT FORM, DEMOGRAPHIC DATA FORM, AND HUMAN SUBJECTS APPROVAL FORM

APPENDIX E

INTERVIEW COVER LETTER

July 2, 1986

Dear CAD/CAM Technician,

I am a doctoral student at Michigan State University completing work for my doctoral dissertation. This dissertation is a study of the duties and tasks performed by CAD/CAM technicians. A duty is a large segment of work performed by an individual. It is one of the distinct major activities involved in the work performed, and is composed of several related tasks. A task is a job activity, or set of activities which, if begun by an individual, is most generally completed by that person. It is of such a nature that it is not generally practical to further subdivide the operation so that more than one worker might specialize in doing various parts of it.

The product of this study will be a validated duty and task listing along with guidelines for utilizing these duties and tasks in developing a training program for CAD/CAM technicians.

If you are willing to participate in the study, I am requesting you sign the attach consent form.

Sincerely,

Donald R. Boyer

CONSENT FORM

I have read the explanatory letter about the study on CAD/CAM technicians being conducted by Donald R. Boyer, a doctoral student at Michigan State University.

I understand that may participation in this study is totally voluntary and that I may elect to participate in all or part of the study. Moreover, I understand I may withdraw my consent at any time without any recrimination. I understand that the product of this study could be used to develop curriculum to train people as CAD/CAM technicians. I understand I will not be kept anonymous as a participant in this study unless I indicate so. I understand that on request and within these restrictions the results of this study will be made available to me.

____
Signature

____
Date

I would like my name and company

kept anonymous ____________________________
Signature

DEMOGRAPHIC INFORMATION REQUESTED DURING INTERVIEW

Thank you agreeing to participate in my study of CAD/CAM technicians. The objective of this research is to identify the duties and tasks performed by CAD/CAM technicians. First I would like you to complete the following information.

Your name: ________________________________

Job title: ________________________________

Company name: ______________________________

Work phone number: ________________________

How long have you operated a CAD/CAM system? __________

How long have you supervised CAD/CAM technicians? __________

What type of CAD/CAM system do you use?

Hardware: ______________________________

Software: ______________________________

What type of industrial application do you use your CAD/CAM system for?

_____A. Automotive industry

_____B. Nonautomotive industry

Do you feel generic CAD/CAM system training is sufficient for job entry? (yes or No)

Next complete the attached task analysis work sheets. Mark either yes or no to the first question (Is this task performed?). If you mark yes to this first question then indicate the frequency this task is performed and mark if this task is required for job entry. If you mark no, go to the next task. Repeat this process for each task statement.

Thank you for your participation in this study.

MICHIGAN STATE UNIVERSITY

UNIVERSITY COMMITTEE ON RESEARCH INVOLVING
HUMAN SUBJECTS (UCRIHS)
238 ADMINISTRATION BUILDING
(517) 355-2186

EAST LANSING • MICHIGAN • 48824-1046

July 8, 1986

Mr. Donald R. Boyer
1714 Danby Lane S.E.
East Grand Rapids, Michigan 49506

Dear Mr. Boyer:

Subject: Proposal Entitled, "An Occupational Analysis of CAD/CAM Technicians with Models and Guidelines for Developing a Training Program"

UCRIHS' review of the above referenced project has now been completed. I am pleased to advise that the rights and welfare of the human subjects appear to be adequately protected and the Committee, therefore, approved this project at its meeting on July 7, 1986.

You are reminded that UCRIHS approval is valid for one calendar year. If you plan to continue this project beyond one year, please make provisions for obtaining appropriate UCRIHS approval prior to July 7, 1987.

Any changes in procedures involving human subjects must be reviewed by the UCRIHS prior to initiation of the change. UCRIHS must also be notified promptly of any problems (unexpected side effects, complaints, etc.) involving human subjects during the course of the work.

Thank you for bringing this project to our attention. If we can be of any future help, please do not hesitate to let us know.

Sincerely,

Henry E. Bredeck
Chairman, UCRIHS

HEB/jms

cc: Dr. George Ferns

APPENDIX F

TASK ANALYSIS CHECK SHEET FOR CAD/CAM TECHNICIANS

APPENDIX F

(INTERVIEW FORMAT SECTION 4)
TASK ANALYSIS CHECK SHEET FOR CAD/CAM TECHNICIANS

DUTIES AND TASKS	YES	NO	FREQUENCY OF PERFOMING THE TASK: DAILY	WEEKLY	MONTHLY	LESS THAN MONTHLY	IMPORTANCE FOR JOB ENTRY: ESSEN-TIAL	VERY DESIRABLE	DESIRABLE	UNNEC-ESSARY	NOT SURE
DUTY A: Manipulate Mechanical Drawing Information											
A1. Set-up and take-down command menu.											
A2. Set-up and take-down library menu.											
A3. Modify a grid.											
A4. Generate a 2D multiview drawing of a part using a function/alphanumeric key board.											
A5. Generate a 2D multiview drawing of a part using a graphics tablet.											
A6. Generate a 2D multiview drawing of a part using a light pen.											
A7. Generate a 2D multiview drawing of a part using a joystick or mouse.											
A8. Create points.											
A9. Create lines by digitizing.											
A10. Create lines by using the absolute coordinate system (Hor. Dis. X, Ver. Dis. Y)											
A11. Create lines by using the incremental coordinate system.											
A12. Create lines by using the polar Coordinate system.											
A13. Create lines parallel.											
A14. Create lines Perpendicular.											
A15. Create circles by digitizing.											
A16. Create circles by keyboard input.											

(INTERVIEW FORMAT SECTION 4)

TASK ANALYSIS CHECK SHEET FOR CAD/CAM TECHNICIANS

DUTIES AND TASKS	YES	NO	FREQUENCY OF PERFOMING THE TASK: DAILY	WEEKLY	MONTHLY	LESS THAN MONTHLY	IMPORTANCE FOR JOB ENTRY: ESSEN-TIAL	VERY DESIRABLE	DESIRABLE	UNNEC-ESSARY	NOT SURE
A17. Create arcs by digitizing.											
A18. Create arcs by keyboard input.											
A19. Crate fillets.											
A20. Edit existing geometry (points, lines, circles or arcs)											
A21. Zoom in or out on a drawing.											
A22. Insert text.											
A23. Edit text.											
A24. Insert library part symbols.											
A25. Layer information in the system.											
A26. Move existing entities.											
A27. Rotate existing entities.											
A28. Mirror existing entities.											
A29. Delete existing entities.											
A30. Copy existing entities.											
A31. Generate a 3D pictorial drawing of a part.											
A32. Generate cross-hatching for a section view automatically of a solid model.											
A33. Generate cross-hatching for a section view manually.											
A34. Create a single auxiliary view of a surface.											
A35. Create multiple auxiliary views of an object.											
A36. Create a ruled surface.											

(INTERVIEW FORMAT SECTION 4)
TASK ANALYSIS CHECK SHEET FOR CAD/CAM TECHNICIANS

DUTIES AND TASKS	YES	NO	FREQUENCY OF PERFOMING THE TASK DAILY	WEEKLY	MONTHLY	LESS THAN MONTHLY	IMPORTANCE FOR JOB ENTRY ESSENTIAL	VERY DESIRABLE	DESIRABLE	UNNECESSARY	NOT SURE
A37. Create a surface by rotation.											
A38. Create a surface from a wire frame model.											
A39. Blend two surfaces together (warped surfaces).											
A40. Create splines or curved lines.											
A41. Dimension a working drawing automatically.											
A42. Place dimensions on a drawing one by one.											
A43. Move existing dimensions.											
A44. Delete dimensions.											
A45. Place tolerances on size, location and angle dimensions.											
A46. Place geometric tolerance symbols on shapes.											
A47. Place true position tolerances on hole locations.											
A48. Create bill of materials.											
A49. Create an assembly drawing form existing part data.											
A50. Print hard copy of data or drawing on a pen plotter.											
A51. Print hard copy of data on a printer.											
A52. Print hard copy of data on a electrostatic plotter.											
A53. Check finish print for errors.											

(INTERVIEW FORMAT SECTION 4)
TASK ANALYSIS CHECK SHEET FOR CAD/CAM TECHNICIANS

DUTIES AND TASKS	YES	NO	FREQUENCY OF PERFORMING THE TASK: DAILY	WEEKLY	MONTHLY	LESS THAN MONTHLY	IMPORTANCE FOR JOB ENTRY: ESSENTIAL	VERY DESIRABLE	DESIRABLE	UNNECESSARY	NOT SURE
DUTY D: GENERATE ELECTRONIC CIRCUIT DESIGNS											
D1. Design block diagrams.											
D2. Design schematic diagrams.											
D3. Run circuit emulation on CAD system.											
D4. Manually (one by one) place components on a printed circuit board layout.											
D5. Automatically place components on a printed circuit board layout.											
D6. Generate a foil pattern of a printed circuit board via the CAD/CAM system.											
D7. Check the design of the printed circuit board.											
D8. Produce a database for manufacturing a printed circuit board to include: 1. schematic drawing 2. assembly drawing 3. parts list 4. circuit board detail drawing 5. PC art work on board 6. hole chart (drill drawing)											

(INTERVIEW FORMAT SECTION 4)
TASK ANALYSIS CHECK SHEET FOR CAD/CAM TECHNICIANS

DUTIES AND TASKS	YES	NO	FREQUENCY OF PERFOMING THE TASK DAILY	WEEKLY	MONTHLY	LESS THAN MONTHLY	IMPORTANCE FOR JOB ENTRY ESSEN-TIAL	VERY DESIRABLE	DESIRABLE	UNNEC-ESSARY	NOT SURE
DUTY C: GENERATE PART PROGRAM											
C1. Determine coordinate system to be used (absolute or incremental system).											
C2. Generate or access part by using a part programming language based on task C1.											
C3. Develop a work piece sequence of operations for one machine.											
C4. Develop a work piece sequence of operations for multi-machines.											
C5. Develop a work piece sequence of operations to include robotic applications.											
C6. Develop a work piece sequence of operations for a total work-cell.											
C7. Select machine tool to be used (drill).											
C8. Select machine tool to be used (milling machine).											
C9. Select machine tool to be used (lathe).											
C10. Select machine tool to be used (grinder).											

(INTERVIEW FORMAT SECTION 4)

TASK ANALYSIS CHECK SHEET FOR CAD/CAM TECHNICIANS

DUTIES AND TASKS	YES	NO	FREQUENCY OF PERFOMING THE TASK: DAILY	WEEKLY	MONTHLY	LESS THAN MONTHLY	IMPORTANCE FOR JOB ENTRY: ESSENTIAL	VERY DESIRABLE	DESIRABLE	UNNECESSARY	NOT SURE
C11. Select machine tool to be used (EDM).											
C12. Select tooling based on material being used.											
C13. Select tooling based on finish desired.											
C14. Input machining parameters (speeds, feeds, tool change information, etc.)											
C15. Document the tooling and manufacturing process.											
C16. Select/design work-holding fixtures.											
C17. Generate computer tool paths.											
C18. Invoke post processor or mainframe program.											
C19. Perform tool path verification on CRT.											
C20. Edit tool path motion.											
C21. Generate output media (from printer or plotter).											
C22. Delete and regenerate corrected tool path information for manufacturing.											

(INTERVIEW FORMAT SECTION 4)

TASK ANALYSIS CHECK SHEET FOR CAD/CAM TECHNICIANS

DUTIES AND TASKS	YES	NO	FREQUENCY OF PERFOMING THE TASK: DAILY	WEEKLY	MONTHLY	LESS THAN MONTHLY	IMPORTANCE FOR JOB ENTRY: ESSENTIAL	VERY DESIRABLE	DESIRABLE	UNNECESSARY	NOT SURE
DUTY D: PERFORM DATA BASE MAINTENANCE											
D1. Remove files from disc.											
D2. Reload files to disc.											
D3. Create files.											
D4. Edit files.											
D5. Delete files.											
D6. Move and copy files.											
D7. Back-up files.											
D8. Append files.											
D9. Check data base.											
D10. Pack data base.											
D11. Sort data base.											
D12. Create directories.											
D13. Remove directories.											
D14. Program a graphics menu file.											
D15. Format blank diskette.											
D16. Run and load a tape drive computer system.											

(INTERVIEW FORMAT SECTION 4)
TASK ANALYSIS CHECK SHEET FOR CAD/CAM TECHNICIANS

DUTIES AND TASKS	YES	NO	FREQUENCY OF PERFOMING THE TASK				IMPORTANCE FOR JOB ENTRY				
			DAILY	WEEKLY	MONTHLY	LESS THAN MONTHLY	ESSEN-TIAL	VERY DESIRABLE	DESIRABLE	UNNEC-ESSARY	NOT SURE
DUTY B: BUILD COMPONENT LIBRARIES											
B1. Create library manually as required.											
B2. Create library automatically through a series of macro routines.											
B3. Build a specific operation file for machining (milling routines etc.).											
DUTY F: INTERPRET AND READ BLUEPRINTS											
F1. Interpret basic views in a working drawing.											
F2. Interpret basic dimensions on a working drawing.											
F3. Interpret toleranced dimensions on a working drawing.											
F4. Calculate basic dimensions where tolerancing is not bilateral.											
F5. Interpret geometrical tolerance symbols.											

(INTERVIEW FORMAT SECTION 4)
TASK ANALYSIS CHECK SHEET FOR CAD/CAM TECHNICIANS

DUTIES AND TASKS	YES	NO	FREQUENCY OF PERFOMING THE TASK DAILY	WEEKLY	MONTHLY	LESS THAN MONTHLY	IMPORTANCE FOR JOB ENTRY ESSEN-TIAL	VERY DESIRABLE	DESIRABLE	UNNEC-ESSARY	NOT SURE
DUTY G: COMPUTE ENGINEERING AND TECHNICAL DATA											
G1. Convert measurements from the English to the Metric system.											
G2. Apply principles of plane geometry (constructions, parallel lines and planes, triangles etc.).											
G3. Apply principles of descriptive geometry (intersections of lines, planes, solids, true size and shape, etc.).											
G4. Apply principles of algebra (scientific notation, simultaneous equations, quadratic equations, etc.).											
G5. Apply principles of trigonometry (solution of triangles using sines and cosines etc.).											
G6. Apply principles of analytical geometry for compound angles and intersections etc.											

(INTERVIEW FORMAT SECTION 4)

TASK ANALYSIS CHECK SHEET FOR CAD/CAM TECHNICIANS

DUTIES AND TASKS	YES	NO	FREQUENCY OF PERFOMING THE TASK: DAILY	WEEKLY	MONTHLY	LESS THAN MONTHLY	IMPORTANCE FOR JOB ENTRY: ESSENTIAL	VERY DESIRABLE	DESIRABLE	UNNECESSARY	NOT SURE
DUTY H: COMMUNICATE ENGINEERING AND TECHNICAL DATA											
H1. Read and interpret highly technical literature.											
H2. Write technical reports and instructions.											
H3. Give and receive instructions verbally.											
H4. Give written instructions.											
H5. Record and document necessary information.											
H6. Sketch basic concepts.											
H7. Generate specifications.											
DUTY I: PERFORM SYSTEM START-UP AND SHUT-DOWN ACTIVITIES											
I1. Power-up and initial boot-up of system.											
I2. Log in on system.											
I3. Perform crash recovery procedures.											
I4. Shut-Down system.											
I5. Perform daily Maintenance of the printer.											
I6. Perform daily maintenance of the computer hardware.											

(INTERVIEW FORMAT SECTION 4)
TASK ANALYSIS CHECK SHEET FOR CAD/CAM TECHNICIANS

DUTIES AND TASKS	YES	NO	FREQUENCY OF PERFOMING THE TASK: DAILY	WEEKLY	MONTHLY	LESS THAN MONTHLY	IMPORTANCE FOR JOB ENTRY: ESSENTIAL	VERY DESIRABLE	DESIRABLE	UNNECESSARY	NOT SURE
DUTY J: PERFORM DESIGN ACTIVITIES											
J1. Design stamping dies.											
J1a. Read and interpret stamping die drawings.											
J2. Design piercing dies.											
J2a. Read and interpret piercing die drawings.											
J3. Design blanking dies.											
J3a. Read and interpret blanking die drawings.											
J4. Design forming dies.											
J5. Design progressive dies.											
J5a. Read and interpret progressive dies drawings.											
J6. Design plastic injection molds.											
J6a. Read and interpret plastic injection mold drawings.											
J7. Design vacuum molds.											
J7a. Read and interpret vacuum mold drawings.											
J8. Design blow molds.											
J8a. Read and interpret blow mold drawings.											
J9. Determine mold flow on the CAD/CAM system.											
J10. Design jigs and fixtures.											
J11. Produce product designs.											
J12. Produce machine designs.											
J13. Produce weldment drawings.											
J14. Detail a designed part.											
J15. Create modifications on a original designed part.											

(INTERVIEW FORMAT SECTION 4)

TASK ANALYSIS CHECK SHEET FOR CAD/CAM TECHNICIANS

DUTIES AND TASKS	YES	NO	FREQUENCY OF PERFORMING THE TASK: DAILY	WEEKLY	MONTHLY	LESS THAN MONTHLY	IMPORTANCE FOR JOB ENTRY: ESSENTIAL	VERY DESIRABLE	DESIRABLE	UNNECESSARY	NOT SURE
J16. Measure an existing part to generate dimensions, using metrology, for a drawing.											
DUTY K: PERFORM ENGINEERING FUNCTIONS											
K1. Use finite element modeling for structural analysis.											
K2. Use mechanics/Kinematics to determine movements within a work area.											
DUTY L: INTERPRET OR CREATE COMPUTER SOFTWARE PROGRAMS											
L1. Interpret or create programs in BASIC language.											
L2. Interpret or create programs in FORTRAN language.											
L3. Interpret or create programs in PASCAL language.											
L4. Interpret or create programs in "C" language.											
L5. Interpret or create programs in APT language.											
L6. Interpret or create programs in Compact II language.											
L7. Interpret or create programs in other computer languages (______________).											
L8. Interpret or create manual NC part programs.											

APPENDIX G

THIRTY-SIX PEOPLE INTERVIEWED IN THE CAD/CAM DUTY AND TASK LIST SURVEY

APPENDIX G

PEOPLE INTERVIEWED
IN THE CAD/CAM DUTY AND TASK LISTING SURVEY

(1) Boyer, Pat
NC Programmer
AUTODIE Corp.
Grand Rapids MI
616-454-9361
System: Gerber autograph & IBM GM/CGS
Application: Automotive
SIC: 3544 ((Tools, dies, jigs and fixtures)

(2) Buckley, John
Technical Services Manager
Holland Hitch Co.
Holland MI
616-396-6501
System: Graftek/GMS
Application: Automotive
SIC: 3714 (Motor vehicle parts and accessories)

(3) Bulinger, Marty
Production Engineer
McDonnell Douglas Electronics Co.
616-494-1090
System: DEC/UniGraphics II
IBM/AUTOCAD
Application: Nonautomotive
SIC: 3728 (Aircraft Equip.)

(4) Freeman, Dan
President
CIMTECH Inc.
Grand Rapids MI .
616-676-9485
System: Gerber Masscomp
Application: Nonautomotive
SIC: None (Design job-shop)

(5) Hart, Robert
Manager CNC Systems
AUTODIE Corp.
Grand Rapids MI
616-454-9361
System: IBM GM-CGS
Gerber
Application: Automotive
SIC: 3544 (Tools and dies and fixtures)

(6) Kadzban, Mark
CAD Supervisor
Quality Die and Mold Corp.
Grand Rapids Mich.
616-531-3500
System: Prime PDGS
Application: Nonautomotive
SIC: 3544 (Tool and die, jig and fixture)

(7) Klamt, Nancy
CAD/CAM Operator
Prince Corp.
Holland MI
616-394-8183
System: Computervision
Application: Automotive
SIC: 3542 Machine tools metal forming
3544 Tools and dies, jigs and fixtures
3714 Motor vehicle parts and accessories

(8) Kelco, Gene
Design Engineer
General Motors Buick, Oldsmobile, Cadilac,
Lansing MI
517-339-9436
System: IBM CADAM & CATIA
Application: Automotive
SIC: 3711 (Motor vehicle and car bodies)

(9) Kleiman, Dennis
VP and CAD/CAM Operator
Precision MFG
Holland MI
616-392-3058
System: Graftek/GMS
Application: Nonautomotive
SIC: 3732-719 Boats other (propeller)

(10) Lapointe, Dave
N/C Applications CAD/CAM Operator
Livernois Engineering Co.
Dearborn Mi.
313- 278-0200
System: Data General/ANVIL 4000 & 5000
Application: Automotive
SIC: 3542 (Machine tools, metal forming)

(11) LaRaia, Michael
Manager or Computer Graphics
Koltanbar Engineering Co.
Troy MI
313-362-2400
System: Applicon
Application: Nonautomotive
SIC: 3544 (Tool and dies and jigs and fixtures)
3569 (Machinery general)

(12) Latva, John
System Manager (CAD/CAM)
Greenville Tool and Die
Greenville MI
System: Computervision CADDS 4X
Application: Automotive
SIC: 3544 (Tools and dies, jigs and fixtures)

(13) Lodewyk, Larry
CAM Die Maker
General Motors CPC
Grand Rapids MI
616-642-5579
System: IBM GM/CGS
Application: Automotive
SIC: 3499 (Metal products, fabrication misc.)

(14) Lucas, Phillip
Systems Administrator
Progressive Blasting
Grand Rapids MI
616-957-0871
System: Prime Medusa, GNC,STG
Application: Nonautomotive
SIC: 3569 (Machinery, General Indus.)

(15) Mastopietro, John
Computer Graphics Supt.
Livernois Engineering
313-278-0200
System: Prime PDGS
Application: Automotive
SIC: 3542 (Machine tools, metal forming)

(16) Miles, Brad
Supervisor Computer Graphics
General Motors (Buick, Oldsmobile, Cadilac)
Lansing MI
517-377-5106
System: IBM GM-CGS, CADAM, CATIA
Application: Automotive
SIC: (3711 Motor vehicle and car bodies)

(17) Mozer, Peter
Vice,Pres. of Advanced Technology
Delta Model and Mold Co.
Troy MI
313-689-5454
Systems: CIMLINC & CIMSURF
Prime PDGS
Application: Automotive
SIC: 3544 (tools and die, jigs and fixtures)

(18) Peterson, Cris
Chief Drafter
Motor Wheel Corp.
Lansing MI
517-337-5826
System: IBM CADAM
Application: Automotive
SIC: 3714 (Motor vehicle parts and accessories)

(19) Sheely, Kevin
Design Draftsman
Vicker Inc.
Troy MI
313-280-3066
System: CALMA/DDM-APOLLO & SDRC
Application: Nonautomotive
SIC: 3561 Pumps and equipment
3599 Machinery
3494 Valves and Pipe fittings
3714 Motor vehicle parts and accessories
3428 Aircraft Equipment

(20) Simmers, Vern
CAD/CAM Manager
Prince Corp.
Holland MI
616- 392-5151
System: Computervision CADDS 4X
Application: Automotive
SIC: 3542 (Machine tools & metal forming)
3544 (Tools and dies, jigs and fixtures)
3714 (Motor vehicle parts and accessories)

(21) Tindle, Randy
Manager CAD/CAM Operations
C.L. Frost Inc.
Grand Rapids MI
616-453-7781
System: IBM CADAM
Application: Nonautomotive
SIC: 3562 (Bearings and Ball and Roller)
3535 (Conveyors and equipment)

(22) Trent, Cliff
Supervisor Design and Drafting
Vickers Inc.
Troy MI
313-280-3066
Systems: CALMA/DDM
Apollo
Data General
Application: Nonautomotive
SIC: 3499 (Machinery)
3494 (Values and pipe fittings)
3714 (Motor vehicle parts and acces.)
3728 (Aircraft)

(23) Walkotten, Richard
Associate Programmer Analyst
General-Motors-CPC
Grand Rapids Mich.
616-247-5579
System: CADLINC
Application: Automotive
SIC: 3499 (Metal Product Fabrication)

(24) Westbrook, Ken
CAD/CAM Plan Activity
General Motors CPC
Warren MI
313-492-6184
System: IBM GM/CGS
Application: Automotive
SIC: 3711 Motor vehicle and car bodies
3714 Motor vehicle parts
3465 Stampings Auto

(25) Wyckoff, Tim
CAD/CAM Operator
Greenville Tool and Die
Greenville MI
616-754-5693
System: Computervision CADDS 4X
Application: Automotive
SIC: 3544 (Tools, die and jigs and fixtures)

NOTE: The technician names and company names have been omitted from the remaining list because the technicians asked to be kept anonymous.

(26) CAD/CAM Manager
Grand Rapids Mi.
System: Prime ACU-CAR (Olmsed)
Prime PDGS
Application: Nonautomotive
SIC: 3079 (Plastics, products misc.)

(27) Systems Manager & CAD/CAM Operator
Sterling Heights MI
System: DEC/CAMAX
Application: Combination trans. Nonautomotive
SIC: 3079 (Plastics Products misc.)

(28) Automation and Controls Specialist
Lincon Park MI
System: Intergraph
Application: Automotive
SIC: 3714 (Motor Vehicle parts and accessories)

(29) Section Manager
Grand Rapids MI
System: Applicon
Application: Nonautomotive
SIC: 3764 (Space propulsion)
3823 (Instruments, process control)
3825 (Instruments, electronic measuring)
3829 (Measuring and controlling devices)

(30) Supervisor CAD/CAM Operations
Dearborn Mi.
Systems: CV CADDS 4X
Prime Lundy PDGS
Application: Automotive
SIC: 3325 (Foundries and Steel Misc.)

(31) Systems Analyst (CAD Operator)
Grand Rapids MI
System: DEC/UniGraphics II
Application: Nonautomotive
SIC: 3728 (Air Craft Equip. Misc.)

(32) Drafter III
Holland MI
616-392-5961
System: Computervision CADDS 4X
Application: Nonautomotive
SIC: 2521 (Furniture office wood)
2522 (Furniture office metal)

(33) Supervisor of Tool and Die CAM
Grand Rapids MI
System: IBM GM/CGS
CADLINK
Application: Automotive
SIC: 3499 (Metal Product Fabricated)

(34) N/C Development Engineer
Lincoln Park MI
System: Intergraph
Application: Automotive
SIC: 3714 (Motor vehicle parts and accessories)

(35) Manufacturing Designer
Wyoming MI
System: IBM GM-CGS
Application: Automotive
SIC: 3714 (motor vehicle parts and accessories)

(36) Supervisor CAD/CAM
Troy Mich.
System: Prime PDGS
Calma DG DDM
Application: Nonautomotive
SIC: None (Design job-shop)

APPENDIX H

ORIGINAL TASK LIST

APPENDIX H

ORIGINAL TASK LIST

DUTY AND TASKS	AUTOMOTIVE TOTAL YES	AUTOMOTIVE PERCENT OF 21	NONAUTOMOTIVE TOTAL YES	NONAUTOMOTIVE PERCENT OF 15	GRAND TOTAL YES	PERCENT OF 36
DUTY-A	Manipulate Mechanical Drawing Information					
A1	13.00	61.90%	8.00	53.33%	21.00	58.33%
A2	11.00	52.38%	8.00	53.33%	19.00	52.78%
A3	8.00	38.10%	11.00	73.33%	19.00	52.78%
A4	15.00	71.43%	13.00	86.67%	28.00	77.78%
A5	16.00	76.19%	10.00	66.67%	26.00	72.22%
A6	10.00	47.62%	3.00	20.00%	13.00	36.11%
A7	8.00	38.10%	9.00	60.00%	17.00	47.22%
A8	21.00	100.00%	15.00	100.00%	36.00	100.00%
A9	19.00	90.48%	10.00	66.67%	29.00	80.56%
A10	19.00	90.48%	14.00	93.33%	33.00	91.67%
A11	17.00	80.95%	12.00	80.00%	29.00	80.56%
A12	16.00	76.19%	10.00	66.67%	26.00	72.22%
A13	21.00	100.00%	15.00	100.00%	36.00	100.00%
A14	21.00	100.00%	15.00	100.00%	36.00	100.00%
A15	15.00	71.43%	11.00	73.33%	26.00	72.22%
A16	19.00	90.48%	14.00	93.33%	33.00	91.67%
A17	16.00	76.19%	9.00	60.00%	25.00	69.44%
A18	20.00	95.24%	13.00	86.67%	33.00	91.67%
A19	21.00	100.00%	15.00	100.00%	36.00	100.00%
A20	21.00	100.00%	15.00	100.00%	36.00	100.00%
A21	21.00	100.00%	15.00	100.00%	36.00	100.00%
A22	20.00	95.24%	15.00	100.00%	35.00	97.22%
A23	20.00	95.24%	15.00	100.00%	35.00	97.22%
A24	15.00	71.43%	14.00	93.33%	29.00	80.56%
A25	19.00	90.48%	12.00	80.00%	31.00	86.11%
A26	21.00	100.00%	15.00	100.00%	36.00	100.00%
A27	21.00	100.00%	15.00	100.00%	36.00	100.00%
A28	21.00	100.00%	15.00	100.00%	36.00	100.00%
A29	21.00	100.00%	15.00	100.00%	36.00	100.00%
A30	21.00	100.00%	14.00	93.33%	35.00	97.22%
A31	18.00	85.71%	14.00	93.33%	32.00	88.89%
A32	8.00	38.10%	8.00	53.33%	16.00	44.44%
A33	10.00	47.62%	12.00	80.00%	22.00	61.11%
A34	17.00	80.95%	15.00	100.00%	32.00	88.89%
A35	19.00	90.48%	15.00	100.00%	34.00	94.44%
A36	17.00	80.95%	14.00	93.33%	31.00	86.11%
A37	17.00	80.95%	14.00	93.33%	31.00	86.11%
A38	19.00	90.48%	11.00	73.33%	30.00	83.33%
A39	19.00	90.48%	11.00	73.33%	30.00	83.33%
A40	21.00	100.00%	15.00	100.00%	36.00	100.00%
A41	8.00	38.10%	11.00	73.33%	19.00	52.78%
A42	20.00	95.24%	14.00	93.33%	34.00	94.44%
A43	19.00	90.48%	15.00	100.00%	34.00	94.44%
A44	19.00	90.48%	15.00	100.00%	34.00	94.44%
A45	19.00	90.48%	14.00	93.33%	33.00	91.67%
A46	14.00	66.67%	14.00	93.33%	28.00	77.78%
A47	11.00	52.38%	13.00	86.67%	24.00	66.67%
A48	9.00	42.86%	9.00	60.00%	18.00	50.00%
A49	11.00	52.38%	13.00	86.67%	24.00	66.67%
A50	16.00	76.19%	14.00	93.33%	30.00	83.33%
A51	16.00	76.19%	11.00	73.33%	27.00	75.00%
A52	17.00	80.95%	3.00	20.00%	20.00	55.56%
A53	17.00	80.95%	13.00	86.67%	30.00	83.33%
DUTY-B	Generate Electronic Circuit Designs					
B1	2.00	9.52%	3.00	20.00%	5.00	13.89%
B2	3.00	14.29%	5.00	33.33%	8.00	22.22%
B3	2.00	9.52%	0.00	0.00%	2.00	5.56%
B4	2.00	9.52%	2.00	13.33%	4.00	11.11%
B5	2.00	9.52%	1.00	6.67%	3.00	8.33%

ORIGINAL TASK LIST

DUTY AND TASKS	AUTOMOTIVE TOTAL YES	AUTOMOTIVE PERCENT OF 21	NONAUTOMOTIVE TOTAL YES	NONAUTOMOTIVE PERCENT OF 15	GRAND TOTAL YES	PERCENT OF 36
B6	2.00	9.52%	3.00	20.00%	5.00	13.89%
B7	2.00	9.52%	2.00	13.33%	4.00	11.11%
B8	1.00	4.76%	1.00	6.67%	2.00	5.56%
DUTY-C	Generate Part Program					
C1	17.00	80.95%	8.00	53.33%	25.00	69.44%
C2	13.00	61.90%	5.00	33.33%	18.00	50.00%
C3	16.00	76.19%	8.00	53.33%	24.00	66.67%
C4	10.00	47.62%	5.00	33.33%	15.00	41.67%
C5	2.00	9.52%	2.00	13.33%	4.00	11.11%
C6	3.00	14.29%	2.00	13.33%	5.00	13.89%
C7	12.00	57.14%	6.00	40.00%	18.00	50.00%
C8	16.00	76.19%	6.00	40.00%	22.00	61.11%
C9	7.00	33.33%	3.00	20.00%	10.00	27.78%
C10	7.00	33.33%	1.00	6.67%	8.00	22.22%
C11	7.00	33.33%	2.00	13.33%	9.00	25.00%
C12	14.00	66.67%	4.00	26.67%	18.00	50.00%
C13	14.00	66.67%	4.00	26.67%	18.00	50.00%
C14	15.00	71.43%	6.00	40.00%	21.00	58.33%
C15	14.00	66.67%	7.00	46.67%	21.00	58.33%
C16	7.00	33.33%	6.00	40.00%	13.00	36.11%
C17	12.00	57.14%	10.00	66.67%	22.00	61.11%
C18	17.00	80.95%	8.00	53.33%	25.00	69.44%
C19	16.00	76.19%	9.00	60.00%	25.00	69.44%
C20	17.00	80.95%	8.00	53.33%	25.00	69.44%
C21	15.00	71.43%	11.00	73.33%	26.00	72.22%
C22	19.00	90.48%	8.00	53.33%	27.00	75.00%
DUTY-D	Perform Data Base Maintenance					
D1	17.00	80.95%	13.00	86.67%	30.00	83.33%
D2	18.00	85.71%	11.00	73.33%	29.00	80.56%
D3	18.00	85.71%	15.00	100.00%	33.00	91.67%
D4	18.00	85.71%	15.00	100.00%	33.00	91.67%
D5	19.00	90.48%	15.00	100.00%	34.00	94.44%
D6	19.00	90.48%	15.00	100.00%	34.00	94.44%
D7	17.00	80.95%	12.00	80.00%	29.00	80.56%
D8	15.00	71.43%	9.00	60.00%	24.00	66.67%
D9	13.00	61.90%	10.00	66.67%	23.00	63.89%
D10	16.00	76.19%	6.00	40.00%	22.00	61.11%
D11	12.00	57.14%	7.00	46.67%	19.00	52.78%
D12	9.00	42.86%	10.00	66.67%	19.00	52.78%
D13	11.00	52.38%	9.00	60.00%	20.00	55.56%
D14	7.00	33.33%	10.00	66.67%	17.00	47.22%
D15	9.00	42.86%	6.00	40.00%	15.00	41.67%
D16	10.00	47.62%	13.00	86.67%	23.00	63.89%
DUTY-E	Build Component Libraries					
E1	14.00	66.67%	13.00	86.67%	27.00	75.00%
E2	6.00	28.57%	5.00	33.33%	11.00	30.56%
E3	7.00	33.33%	6.00	40.00%	13.00	36.11%
DUTY-F	Interpret and Read Blueprints					
F1	21.00	100.00%	15.00	100.00%	36.00	100.00%
F2	21.00	100.00%	15.00	100.00%	36.00	100.00%
F3	21.00	100.00%	14.00	93.33%	35.00	97.22%
F4	18.00	85.71%	14.00	93.33%	32.00	88.89%
F5	21.00	100.00%	14.00	93.33%	35.00	97.22%
DUTY-G	Compute Engineering and Technical Data					
G1	21.00	100.00%	9.00	60.00%	30.00	83.33%
G2	21.00	100.00%	15.00	100.00%	36.00	100.00%

ORIGINAL TASK LIST

DUTY AND TASKS	AUTOMOTIVE TOTAL YES	AUTOMOTIVE PERCENT OF 21	NONAUTOMOTIVE TOTAL YES	NONAUTOMOTIVE PERCENT OF 15	GRAND TOTAL YES	PERCENT OF 36
G3	20.00	95.24%	15.00	100.00%	35.00	97.22%
G4	15.00	71.43%	14.00	93.33%	29.00	80.56%
G5	20.00	95.24%	15.00	100.00%	35.00	97.22%
G6	20.00	95.24%	13.00	86.67%	33.00	91.67%
DUTY-H	Communicate Engineering and Technical Data					
H1	18.00	85.71%	10.00	66.67%	28.00	77.78%
H2	10.00	47.62%	10.00	66.67%	20.00	55.56%
H3	21.00	100.00%	14.00	93.33%	35.00	97.22%
H4	18.00	85.71%	14.00	93.33%	32.00	88.89%
H5	20.00	95.24%	14.00	93.33%	34.00	94.44%
H6	18.00	85.71%	15.00	100.00%	33.00	91.67%
H7	13.00	61.90%	10.00	66.67%	23.00	63.89%
DUTY-I	Perform System Start-up and Shut-down Activities					
I1	15.00	71.43%	13.00	86.67%	28.00	77.78%
I2	19.00	90.48%	15.00	100.00%	34.00	94.44%
I3	13.00	61.90%	12.00	80.00%	25.00	69.44%
I4	14.00	66.67%	13.00	86.67%	27.00	75.00%
I5	8.00	38.10%	9.00	60.00%	17.00	47.22%
I6	7.00	33.33%	5.00	33.33%	12.00	33.33%
DUTY-J	Perform Design Activities					
J1	5.00	23.81%	2.00	13.33%	7.00	19.44%
J1A	11.00	52.38%	4.00	26.67%	15.00	41.67%
J2	6.00	28.57%	1.00	6.67%	7.00	19.44%
J2A	12.00	57.14%	2.00	13.33%	14.00	38.89%
J3	8.00	38.10%	1.00	6.67%	9.00	25.00%
J3A	9.00	42.86%	2.00	13.33%	11.00	30.56%
J4	5.00	23.81%	2.00	13.33%	7.00	19.44%
J5	4.00	19.05%	1.00	6.67%	5.00	13.89%
J5A	9.00	42.86%	4.00	26.67%	13.00	36.11%
J6	4.00	19.05%	4.00	26.67%	8.00	22.22%
J6A	8.00	38.10%	6.00	40.00%	14.00	38.89%
J7	1.00	4.76%	1.00	6.67%	2.00	5.56%
J7A	2.00	9.52%	3.00	20.00%	5.00	13.89%
J8	2.00	9.52%	0.00	0.00%	2.00	5.56%
J8A	4.00	19.05%	1.00	6.67%	5.00	13.89%
J9	3.00	14.29%	1.00	6.67%	4.00	11.11%
J10	7.00	33.33%	6.00	40.00%	13.00	36.11%
J11	8.00	38.10%	9.00	60.00%	17.00	47.22%
J12	9.00	42.86%	4.00	26.67%	13.00	36.11%
J13	8.00	38.10%	5.00	33.33%	13.00	36.11%
J14	16.00	76.19%	13.00	86.67%	29.00	80.56%
J15	16.00	76.19%	13.00	86.67%	29.00	80.56%
J16	10.00	47.62%	9.00	60.00%	19.00	52.78%
DUTY-K	Perform Engineering Functions					
K1	4.00	19.05%	2.00	13.33%	6.00	16.67%
K2	5.00	23.81%	3.00	20.00%	8.00	22.22%
DUTY-L	Interpret or Create Computer Software Programs					
L1	11.00	52.38%	5.00	33.33%	16.00	44.44%
L2	8.00	38.10%	6.00	40.00%	14.00	38.89%
L3	1.00	4.76%	2.00	13.33%	3.00	8.33%
L4	5.00	23.81%	2.00	13.33%	7.00	19.44%
L5	9.00	42.86%	5.00	33.33%	14.00	38.89%
L6	0.00	0.00%	1.00	6.67%	1.00	2.78%
L7	6.00	28.57%	7.00	46.67%	13.00	36.11%
L8	8.00	38.10%	6.00	40.00%	14.00	38.89%

APPENDIX I

FINAL TASK LIST

APPENDIX I

FINAL TASK LIST

DUTY AND TASKS	AUTOMOTIVE TOTAL YES	AUTOMOTIVE PERCENT OF 21	NONAUTOMOTIVE TOTAL YES	NONAUTOMOTIVE PERCENT OF 15	GRAND TOTAL YES	PERCENT OF 36
DUTY-A	Manipulate Mechanical Drawing Information					
A1	13	61.90%	8	53.33%	21	58.33%
A2	11	52.38%	8	53.33%	19	52.78%
A3	8	38.10%	11	73.33%	19	52.78%
A4	15	71.43%	13	86.67%	28	77.78%
A5	16	76.19%	10	66.67%	26	72.22%
A8	21	100.00%	15	100.00%	36	100.00%
A9	19	90.48%	10	66.67%	29	80.56%
A10	19	90.48%	14	93.33%	33	91.67%
A11	17	80.95%	12	80.00%	29	80.56%
A12	16	76.19%	10	66.67%	26	72.22%
A13	21	100.00%	15	100.00%	36	100.00%
A14	21	100.00%	15	100.00%	36	100.00%
A15	15	71.43%	11	73.33%	26	72.22%
A16	19	90.48%	14	93.33%	33	91.67%
A17	16	76.19%	9	60.00%	25	69.44%
A18	20	95.24%	13	86.67%	33	91.67%
A19	21	100.00%	15	100.00%	36	100.00%
A20	21	100.00%	15	100.00%	36	100.00%
A21	21	100.00%	15	100.00%	36	100.00%
A22	20	95.24%	15	100.00%	35	97.22%
A23	20	95.24%	15	100.00%	35	97.22%
A24	15	71.43%	14	93.33%	29	80.56%
A25	19	90.48%	12	80.00%	31	86.11%
A26	21	100.00%	15	100.00%	36	100.00%
A27	21	100.00%	15	100.00%	36	100.00%
A28	21	100.00%	15	100.00%	36	100.00%
A29	21	100.00%	15	100.00%	36	100.00%
A30	21	100.00%	14	93.33%	35	97.22%
A31	18	85.71%	14	93.33%	32	88.89%
A33	10	47.62%	12	80.00%	22	61.11%
A34	17	80.95%	15	100.00%	32	88.89%
A35	19	90.48%	15	100.00%	34	94.44%
A36	17	80.95%	14	93.33%	31	86.11%
A37	17	80.95%	14	93.33%	31	86.11%
A38	19	90.48%	11	73.33%	30	83.33%
A39	19	90.48%	11	73.33%	30	83.33%
A40	21	100.00%	15	100.00%	36	100.00%
A41	8	38.10%	11	73.33%	19	52.78%
A42	20	95.24%	14	93.33%	34	94.44%
A43	19	90.48%	15	100.00%	34	94.44%
A44	19	90.48%	15	100.00%	34	94.44%
A45	19	90.48%	14	93.33%	33	91.67%
A46	14	66.67%	14	93.33%	28	77.78%
A47	11	52.38%	13	86.67%	24	66.67%
A48	9	42.86%	9	60.00%	18	50.00%
A49	11	52.38%	13	86.67%	24	66.67%
A50	16	76.19%	14	93.33%	30	83.33%
A51	16	76.19%	11	73.33%	27	75.00%
A52	17	80.95%	3	20.00%	20	55.56%
A53	17	80.95%	13	86.67%	30	83.33%
DUTY-C	Generate Part Program					
C1	17	80.95%	8	53.33%	25	69.44%
C2	13	61.90%	5	33.33%	18	50.00%
C3	16	76.19%	8	53.33%	24	66.67%
C7	12	57.14%	6	40.00%	18	50.00%
C8	16	76.19%	6	40.00%	22	61.11%
C12	14	66.67%	4	26.67%	18	50.00%
C13	14	66.67%	4	26.67%	18	50.00%
C14	15	71.43%	6	40.00%	21	58.33%

FINAL TASK LIST

DUTY AND TASKS	AUTOMOTIVE TOTAL YES	AUTOMOTIVE PERCENT OF 21	NONAUTOMOTIVE TOTAL YES	NONAUTOMOTIVE PERCENT OF 15	GRAND TOTAL YES	PERCENT OF 36
C15	14	66.67%	7	46.67%	21	58.33%
C17	12	57.14%	10	66.67%	22	61.11%
C18	17	80.95%	8	53.33%	25	69.44%
C19	16	76.19%	9	60.00%	25	69.44%
C20	17	80.95%	8	53.33%	25	69.44%
C21	15	71.43%	11	73.33%	26	72.22%
C22	19	90.48%	8	53.33%	27	75.00%
DUTY-D	Perform Data Base Maintenance					
D1	17	80.95%	13	86.67%	30	83.33%
D2	18	85.71%	11	73.33%	29	80.56%
D3	18	85.71%	15	100.00%	33	91.67%
D4	18	85.71%	15	100.00%	33	91.67%
D5	19	90.48%	15	100.00%	34	94.44%
D6	19	90.48%	15	100.00%	34	94.44%
D7	17	80.95%	12	80.00%	29	80.56%
D8	15	71.43%	9	60.00%	24	66.67%
D9	13	61.90%	10	66.67%	23	63.89%
D10	16	76.19%	6	40.00%	22	61.11%
D11	12	57.14%	7	46.67%	19	52.78%
D12	9	42.86%	10	66.67%	19	52.78%
D13	11	52.38%	9	60.00%	20	55.56%
D16	10	47.62%	13	86.67%	23	63.89%
DUTY-E	Build Component Libraries					
E1	14	66.67%	13	86.67%	27	75.00%
DUTY-F	Interpret and Read Blueprints					
F1	21	100.00%	15	100.00%	36	100.00%
F2	21	100.00%	15	100.00%	36	100.00%
F3	21	100.00%	14	93.33%	35	97.22%
F4	18	85.71%	14	93.33%	32	88.89%
F5	21	100.00%	14	93.33%	35	97.22%
DUTY-G	Compute Engineering and Technical Data					
G1	21	100.00%	9	60.00%	30	83.33%
G2	21	100.00%	15	100.00%	36	100.00%
G3	20	95.24%	15	100.00%	35	97.22%
G4	15	71.43%	14	93.33%	29	80.56%
G5	20	95.24%	15	100.00%	35	97.22%
G6	20	95.24%	13	86.67%	33	91.67%
DUTY-H	Read and Interpret Highly Technical Literature					
H1	18	85.71%	10	66.67%	28	77.78%
H2	10	47.62%	10	66.67%	20	55.56%
H3	21	100.00%	14	93.33%	35	97.22%
H4	18	85.71%	14	93.33%	32	88.89%
H5	20	95.24%	14	93.33%	34	94.44%
H6	18	85.71%	15	100.00%	33	91.67%
H7	13	61.90%	10	66.67%	23	63.89%
DUTY-I	Perform System Start-up and Shut-down Activities					
I1	15	71.43%	13	86.67%	28	77.78%
I2	19	90.48%	15	100.00%	34	94.44%
I3	13	61.90%	12	80.00%	25	69.44%
I4	14	66.67%	13	86.67%	27	75.00%
DUTY-J	Perform Design Activities					
J14	16	76.19%	13	86.67%	29	80.56%

FINAL TASK LIST

DUTY AND TASKS	AUTOMOTIVE TOTAL YES	AUTOMOTIVE PERCENT OF 21	NONAUTOMOTIVE TOTAL YES	NONAUTOMOTIVE PERCENT OF 15	GRAND TOTAL YES	PERCENT OF 36
J15	16	76.19%	13	86.67%	29	80.56%
J16	10	47.62%	9	60.00%	19	52.78%

APPENDIX J

RANKING OF THE FINAL TASKS BY PERCENTAGE OF RESPONDENTS PERFORMING THAT TASK

APPENDIX J

RANKING OF THE 105 TASKS
BY PERCENTAGE OF RESPONDENTS PERFORMING THAT TASK

DUTY AND TASKS	AUTOMOTIVE TOTAL YES	AUTOMOTIVE PERCENT OF 21	NONAUTOMOTIVE TOTAL YES	NONAUTOMOTIVE PERCENT OF 15	GRAND TOTAL YES	PERCENT OF 36
A14	21	100.00%	15	100.00%	36	100.00%
A40	21	100.00%	15	100.00%	36	100.00%
F2	21	100.00%	15	100.00%	36	100.00%
A20	21	100.00%	15	100.00%	36	100.00%
A29	21	100.00%	15	100.00%	36	100.00%
A13	21	100.00%	15	100.00%	36	100.00%
A8	21	100.00%	15	100.00%	36	100.00%
A26	21	100.00%	15	100.00%	36	100.00%
A27	21	100.00%	15	100.00%	36	100.00%
A19	21	100.00%	15	100.00%	36	100.00%
F1	21	100.00%	15	100.00%	36	100.00%
A21	21	100.00%	15	100.00%	36	100.00%
G2	21	100.00%	15	100.00%	36	100.00%
A28	21	100.00%	15	100.00%	36	100.00%
A30	21	100.00%	14	93.33%	35	97.22%
A22	20	95.24%	15	100.00%	35	97.22%
F5	21	100.00%	14	93.33%	35	97.22%
A23	20	95.24%	15	100.00%	35	97.22%
H3	21	100.00%	14	93.33%	35	97.22%
F3	21	100.00%	14	93.33%	35	97.22%
G5	20	95.24%	15	100.00%	35	97.22%
G3	20	95.24%	15	100.00%	35	97.22%
A42	20	95.24%	14	93.33%	34	94.44%
A35	19	90.48%	15	100.00%	34	94.44%
A43	19	90.48%	15	100.00%	34	94.44%
D5	19	90.48%	15	100.00%	34	94.44%
H5	20	95.24%	14	93.33%	34	94.44%
A44	19	90.48%	15	100.00%	34	94.44%
D6	19	90.48%	15	100.00%	34	94.44%
I2	19	90.48%	15	100.00%	34	94.44%
A18	20	95.24%	13	86.67%	33	91.67%
A16	19	90.48%	14	93.33%	33	91.67%
H6	18	85.71%	15	100.00%	33	91.67%
A10	19	90.48%	14	93.33%	33	91.67%
A45	19	90.48%	14	93.33%	33	91.67%
D4	18	85.71%	15	100.00%	33	91.67%
D3	18	85.71%	15	100.00%	33	91.67%
G6	20	95.24%	13	86.67%	33	91.67%
F4	18	85.71%	14	93.33%	32	88.89%
A34	17	80.95%	15	100.00%	32	88.89%
H4	18	85.71%	14	93.33%	32	88.89%
A31	18	85.71%	14	93.33%	32	88.89%
A36	17	80.95%	14	93.33%	31	86.11%
A37	17	80.95%	14	93.33%	31	86.11%
A25	19	90.48%	12	80.00%	31	86.11%
A39	19	90.48%	11	73.33%	30	83.33%
A38	19	90.48%	11	73.33%	30	83.33%
D1	17	80.95%	13	86.67%	30	83.33%
G1	21	100.00%	9	60.00%	30	83.33%
A50	16	76.19%	14	93.33%	30	83.33%
A53	17	80.95%	13	86.67%	30	83.33%
G4	15	71.43%	14	93.33%	29	80.56%
A24	15	71.43%	14	93.33%	29	80.56%
A11	17	80.95%	12	80.00%	29	80.56%
J15	16	76.19%	13	86.67%	29	80.56%
D7	17	80.95%	12	80.00%	29	80.56%
D2	18	85.71%	11	73.33%	29	80.56%
A9	19	90.48%	10	66.67%	29	80.56%
J14	16	76.19%	13	86.67%	29	80.56%
I1	15	71.43%	13	86.67%	28	77.78%

RANKING OF THE 105 TASKS
BY PERCENTAGE OF RESPONDENTS PERFORMING THAT TASK

DUTY AND TASKS	AUTOMOTIVE TOTAL YES	AUTOMOTIVE PERCENT OF 21	NONAUTOMOTIVE TOTAL YES	NONAUTOMOTIVE PERCENT OF 15	GRAND TOTAL YES	PERCENT OF 36
A4	15	71.43%	13	86.67%	28	77.78%
A46	14	66.67%	14	93.33%	28	77.78%
H1	18	85.71%	10	66.67%	28	77.78%
E1	14	66.67%	13	86.67%	27	75.00%
A51	16	76.19%	11	73.33%	27	75.00%
I4	14	66.67%	13	86.67%	27	75.00%
C22	19	90.48%	8	53.33%	27	75.00%
A15	15	71.43%	11	73.33%	26	72.22%
C21	15	71.43%	11	73.33%	26	72.22%
A5	16	76.19%	10	66.67%	26	72.22%
A12	16	76.19%	10	66.67%	26	72.22%
C19	16	76.19%	9	60.00%	25	69.44%
C20	17	80.95%	8	53.33%	25	69.44%
C1	17	80.95%	8	53.33%	25	69.44%
C18	17	80.95%	8	53.33%	25	69.44%
A17	16	76.19%	9	60.00%	25	69.44%
I3	13	61.90%	12	80.00%	25	69.44%
D8	15	71.43%	9	60.00%	24	66.67%
A47	11	52.38%	13	86.67%	24	66.67%
A49	11	52.38%	13	86.67%	24	66.67%
C3	16	76.19%	8	53.33%	24	66.67%
D9	13	61.90%	10	66.67%	23	63.89%
D16	10	47.62%	13	86.67%	23	63.89%
H7	13	61.90%	10	66.67%	23	63.89%
A33	10	47.62%	12	80.00%	22	61.11%
C8	16	76.19%	6	40.00%	22	61.11%
C17	12	57.14%	10	66.67%	22	61.11%
D10	16	76.19%	6	40.00%	22	61.11%
C14	15	71.43%	6	40.00%	21	58.33%
A1	13	61.90%	8	53.33%	21	58.33%
C15	14	66.67%	7	46.67%	21	58.33%
D13	11	52.38%	9	60.00%	20	55.56%
A52	17	80.95%	3	20.00%	20	55.56%
H2	10	47.62%	10	66.67%	20	55.56%
J16	10	47.62%	9	60.00%	19	52.78%
A2	11	52.38%	8	53.33%	19	52.78%
D11	12	57.14%	7	46.67%	19	52.78%
D12	9	42.86%	10	66.67%	19	52.78%
A41	8	38.10%	11	73.33%	19	52.78%
A3	8	38.10%	11	73.33%	19	52.78%
C7	12	57.14%	6	40.00%	18	50.00%
C12	14	66.67%	4	26.67%	18	50.00%
A48	9	42.86%	9	60.00%	18	50.00%
C13	14	66.67%	4	26.67%	18	50.00%
C2	13	61.90%	5	33.33%	18	50.00%

APPENDIX K

FREQUENCY WITH WHICH RESPONDENTS PERFORMED THE TASKS

APPENDIX K

FREQUENCY WITH WHICH RESPONDENTS PERFORMED THE TASKS

TASKLIST

DUTY AND TASK	TOTAL YES	DAILY NO. (4)	DAILY PERCENT	WEEKLY NO. (3)	WEEKLY PERCENT	MONTHLY NO. (2)	MONTHLY PERCENT	LESS THAN MONTHLY NO. (1)	LESS THAN MONTHLY PERCENT	MEAN
DUTY-A	Manipulate Mechanical Drawing Information									
A1	21	8	38.10%	7	33.33%	1	4.76%	5	23.81%	2.86
A2	19	7	36.84%	2	10.53%	6	31.58%	4	21.05%	2.63
A3	19	7	36.84%	4	21.05%	4	21.05%	4	21.05%	2.74
A4	28	22	78.57%	5	17.86%	0	0.00%	1	3.57%	3.71
A5	26	26	100.00%	0	0.00%	0	0.00%	0	0.00%	4.00
A8	36	34	94.44%	0	0.00%	1	2.78%	1	2.78%	3.86
A9	29	18	62.07%	5	17.24%	4	13.79%	2	6.90%	3.34
A10	33	30	90.91%	3	9.09%	0	0.00%	0	0.00%	3.91
A11	29	24	82.76%	2	6.90%	1	3.45%	2	6.90%	3.66
A12	26	16	61.54%	4	15.38%	3	11.54%	3	11.54%	3.27
A13	36	35	97.22%	1	2.78%	0	0.00%	0	0.00%	3.97
A14	36	34	94.44%	2	5.56%	0	0.00%	0	0.00%	3.94
A15	26	14	53.85%	5	19.23%	4	15.38%	3	11.54%	3.15
A16	33	31	93.94%	2	6.06%	0	0.00%	0	0.00%	3.94
A17	25	15	60.00%	4	16.00%	5	20.00%	1	4.00%	3.32
A18	33	29	87.88%	3	9.09%	1	3.03%	0	0.00%	3.85
A19	36	31	86.11%	5	13.89%	0	0.00%	0	0.00%	3.86
A20	36	35	97.22%	1	2.78%	0	0.00%	0	0.00%	3.97
A21	36	35	97.22%	1	2.78%	0	0.00%	0	0.00%	3.97
A22	35	31	88.57%	4	11.43%	0	0.00%	0	0.00%	3.89
A23	35	31	88.57%	3	8.57%	1	2.86%	0	0.00%	3.86
A24	29	20	68.97%	7	24.14%	1	3.45%	1	3.45%	3.59
A25	31	26	83.87%	4	12.90%	1	3.23%	0	0.00%	3.81
A26	36	33	91.67%	3	8.33%	0	0.00%	0	0.00%	3.92
A27	36	31	86.11%	5	13.89%	0	0.00%	0	0.00%	3.86
A28	36	28	77.78%	8	22.22%	0	0.00%	0	0.00%	3.78
A29	36	34	94.44%	2	5.56%	0	0.00%	0	0.00%	3.94
A30	35	30	85.71%	5	14.29%	0	0.00%	0	0.00%	3.86
A31	32	18	56.25%	7	21.88%	4	12.50%	3	9.38%	3.25
A33	22	10	45.45%	8	36.36%	1	4.55%	3	13.64%	3.14
A34	32	12	37.50%	15	46.88%	4	12.50%	1	3.13%	3.19
A35	34	15	44.12%	13	38.24%	4	11.76%	2	5.88%	3.21
A36	31	14	45.16%	8	25.81%	4	12.90%	5	16.13%	3.00
A37	31	9	29.03%	10	32.26%	6	19.35%	6	19.35%	2.71
A38	30	18	60.00%	7	23.33%	2	6.67%	3	10.00%	3.33
A39	30	11	36.67%	9	30.00%	4	13.33%	6	20.00%	2.83
A40	36	22	61.11%	11	30.56%	2	5.56%	1	2.78%	3.50
A41	19	10	52.63%	7	36.84%	1	5.26%	1	5.26%	3.37
A42	34	24	70.59%	7	20.59%	3	8.82%	0	0.00%	3.62
A43	34	20	58.82%	11	32.35%	3	8.82%	0	0.00%	3.50
A44	34	23	67.65%	10	29.41%	1	2.94%	0	0.00%	3.65
A45	33	20	60.61%	9	27.27%	2	6.06%	2	6.06%	3.42
A46	28	17	60.71%	6	21.43%	2	7.14%	3	10.71%	3.32
A47	24	16	66.67%	6	25.00%	2	8.33%	0	0.00%	3.58
A48	18	5	27.78%	9	50.00%	3	16.67%	1	5.56%	3.00
A49	24	10	41.67%	10	41.67%	3	12.50%	1	4.17%	3.21
A50	30	19	63.33%	9	30.00%	2	6.67%	0	0.00%	3.57
A51	27	19	70.37%	8	29.63%	0	0.00%	0	0.00%	3.70
A52	20	16	80.00%	4	20.00%	0	0.00%	0	0.00%	3.80
A53	30	19	63.33%	10	33.33%	1	3.33%	0	0.00%	3.60
DUTY-C	Generate Part Program									
C1	25	10	40.00%	9	36.00%	5	20.00%	1	4.00%	3.12
C2	18	9	50.00%	6	33.33%	3	16.67%	0	0.00%	3.33
C3	24	10	41.67%	12	50.00%	2	8.33%	0	0.00%	3.33
C7	18	12	66.67%	4	22.22%	2	11.11%	0	0.00%	3.56
C8	22	17	77.27%	3	13.64%	2	9.09%	0	0.00%	3.68
C12	18	15	83.33%	2	11.11%	1	5.56%	0	0.00%	3.78
C13	18	15	83.33%	2	11.11%	1	5.56%	0	0.00%	3.78

FREQUENCY WITH WHICH RESPONDENTS PERFORMED THE TASKS

TASKLIST

DUTY AND TASK	TOTAL YES	DAILY NO. (4)	DAILY PERCENT	WEEKLY NO. (3)	WEEKLY PERCENT	MONTHLY NO. (2)	MONTHLY PERCENT	LESS THAN MONTHLY NO. (1)	LESS THAN MONTHLY PERCENT	MEAN
C14	21	18	85.71%	2	9.52%	1	4.76%	0	0.00%	3.81
C15	21	16	76.19%	4	19.05%	1	4.76%	0	0.00%	3.71
C17	22	17	77.27%	2	9.09%	1	4.55%	2	9.09%	3.55
C18	25	20	80.00%	2	8.00%	1	4.00%	2	8.00%	3.60
C19	25	19	76.00%	3	12.00%	0	0.00%	3	12.00%	3.52
C20	25	17	68.00%	5	20.00%	1	4.00%	2	8.00%	3.48
C21	26	15	57.69%	3	11.54%	2	7.69%	6	23.08%	3.04
C22	27	18	66.67%	5	18.52%	2	7.41%	2	7.41%	3.44
DUTY-D	Perform Data Base Maintenance									
D1	30	17	56.67%	8	26.67%	5	16.67%	0	0.00%	3.40
D2	29	14	48.28%	11	37.93%	3	10.34%	1	3.45%	3.31
D3	33	22	66.67%	9	27.27%	2	6.06%	0	0.00%	3.61
D4	33	19	57.58%	12	36.36%	2	6.06%	0	0.00%	3.52
D5	34	19	55.88%	12	35.29%	3	8.82%	0	0.00%	3.47
D6	34	19	55.88%	13	38.24%	2	5.88%	0	0.00%	3.50
D7	29	20	68.97%	9	31.03%	0	0.00%	0	0.00%	3.69
D8	24	13	54.17%	6	25.00%	4	16.67%	1	4.17%	3.29
D9	23	16	69.57%	4	17.39%	2	8.70%	1	4.35%	3.52
D10	22	17	77.27%	2	9.09%	3	13.64%	0	0.00%	3.64
D11	19	15	78.95%	1	5.26%	0	0.00%	3	15.79%	3.47
D12	19	4	21.05%	6	31.58%	5	26.32%	4	21.05%	2.53
D13	20	6	30.00%	5	25.00%	6	30.00%	3	15.00%	2.70
D16	23	16	69.57%	3	13.04%	2	8.70%	2	8.70%	3.43
DUTY-E	Build Component Libraries									
E1	27	4	14.81%	8	29.63%	10	37.04%	5	18.52%	2.41
DUTY-F	Interpret and Read Blueprints									
F1	36	36	100.00%	0	0.00%	0	0.00%	0	0.00%	4.00
F2	36	36	100.00%	0	0.00%	0	0.00%	0	0.00%	4.00
F3	35	32	91.43%	2	5.71%	1	2.86%	0	0.00%	3.89
F4	32	24	75.00%	6	18.75%	2	6.25%	0	0.00%	3.69
F5	35	29	82.86%	4	11.43%	2	5.71%	0	0.00%	3.77
DUTY-G	Compute Engineering and Technical Data									
G1	30	20	66.67%	8	26.67%	2	6.67%	0	0.00%	3.60
G2	36	29	80.56%	4	11.11%	2	5.56%	1	2.78%	3.69
G3	35	28	80.00%	6	17.14%	1	2.86%	0	0.00%	3.77
G4	29	11	37.93%	12	41.38%	5	17.24%	1	3.45%	3.14
G5	35	22	62.86%	10	28.57%	0	0.00%	3	8.57%	3.46
G6	33	18	54.55%	11	33.33%	1	3.03%	3	9.09%	3.33
DUTY-H	Read and Interpret Highly Technical Literature									
HI	23	10	43.48%	7	30.43%	3	13.04%	3	13.04%	3.04
H2	20	7	35.00%	6	30.00%	4	20.00%	3	15.00%	2.85
H3	35	32	91.43%	1	2.86%	0	0.00%	2	5.71%	3.80
H4	32	21	65.63%	9	28.13%	0	0.00%	2	6.25%	3.53
H5	34	24	70.59%	9	26.47%	1	2.94%	0	0.00%	3.68
H6	33	20	60.61%	12	36.36%	1	3.03%	0	0.00%	3.58
H7	23	14	60.87%	5	21.74%	2	8.70%	2	8.70%	3.35
DUTY-I	Perform System Start-up and Shut-down Activities									
I1	28	14	50.00%	8	28.57%	6	21.43%	0	0.00%	3.29
I2	34	31	91.18%	2	5.88%	1	2.94%	0	0.00%	3.88
I3	25	14	56.00%	4	16.00%	6	24.00%	1	4.00%	3.24
I4	27	19	70.37%	2	7.41%	4	14.81%	2	7.41%	3.41
DUTY-J	Perform Design Activities									
J14	29	21	72.41%	8	27.59%	3	10.34%	0	0.00%	3.93

FREQUENCY WITH WHICH RESPONDENTS PERFORMED THE TASKS

TASKLIST

DUTY AND TASK	TOTAL YES	DAILY (4) NO.	DAILY (4) PERCENT	WEEKLY (3) NO.	WEEKLY (3) PERCENT	MONTHLY (2) NO.	MONTHLY (2) PERCENT	LESS THAN MONTHLY (1) NO.	LESS THAN MONTHLY (1) PERCENT	MEAN
J15	29	20	68.97%	8	27.59%	0	0.00%	1	3.45%	3.62
J16	19	11	57.89%	4	21.05%	2	10.53%	2	10.53%	3.26

APPENDIX L

IMPORTANCE OF TASKS FOR JOB ENTRY

APPENDIX L

IMPORTANCE OF TASKS FOR JOB ENTRY

DUTY AND TASK	TOTAL NUMBER	ESSENTIAL NO. (4)	ESSENTIAL PERCENT	VERY DESIRABLE NO. (3)	VERY DESIRABLE PERCENT	DESIRABLE NO. (2)	DESIRABLE PERCENT	UNNECESSARY NO. (1)	UNNECESSARY PERCENT	MEAN	STANDARD DEVIATION
A1	21	5	23.81%	2	9.52%	9	42.86%	5	23.81%	2.33	0.25
A2	19	5	26.32%	1	5.26%	9	42.86%	4	21.05%	2.37	0.26
A3	19	3	15.79%	0	0.00	12	63.16%	4	21.05%	2.11	0.22
A4	28	16	57.14%	6	21.43%	4	14.29%	2	7.14%	3.29	0.19
A5	26	16	61.54%	4	15.38%	6	23.08%	0	0.00%	3.38	0.17
A8	36	30	83.33%	2	5.56%	3	8.33%	1	2.78%	3.69	0.13
A9	29	16	55.17%	6	20.69%	6	20.69%	1	3.45%	3.28	0.17
A10	33	26	78.79%	3	9.09%	4	12.12%	0	0.00%	3.67	0.12
A11	29	17	58.62%	6	20.69%	4	13.79%	2	6.90%	3.31	0.18
A12	26	11	42.31%	5	19.23%	8	30.77%	2	7.69%	2.96	0.21
A13	36	28	77.78%	4	11.11%	4	11.11%	0	0.00%	3.67	0.11
A14	36	29	80.56%	3	8.33%	4	11.11%	0	0.00%	3.69	0.11
A15	26	13	50.00%	2	7.69%	7	26.92%	4	15.38%	2.92	0.24
A16	33	24	72.73%	5	15.15%	4	12.12%	0	0.00%	3.61	0.12
A17	25	10	40.00%	2	8.00%	6	24.00%	7	28.00%	2.60	0.26
A18	33	21	63.64%	5	15.15%	7	21.21%	0	0.00%	3.42	0.15
A19	36	23	63.89%	7	19.44%	6	16.67%	0	0.00%	3.47	0.13
A20	36	25	69.44%	7	19.44%	4	11.11%	0	0.00%	3.58	0.12
A21	36	26	72.22%	4	11.11%	6	16.67%	0	0.00%	3.56	0.13
A22	35	27	77.14%	3	8.57%	5	14.29%	0	0.00%	3.63	0.13
A23	35	25	71.43%	3	8.57%	7	20.00%	0	0.00%	3.51	0.14
A24	29	13	44.83%	6	20.69%	7	24.14%	3	11.11%	3.00	0.20
A25	31	14	45.16%	6	19.35%	11	35.48%	0	0.00%	3.10	0.17
A26	36	25	69.44%	3	8.33%	8	22.22%	0	0.00%	3.47	0.14
A27	36	25	69.44%	3	8.33%	8	22.22%	0	0.00%	3.47	0.14
A28	36	23	63.89%	5	13.89%	7	19.44%	1	3.70%	3.39	0.15
A29	36	27	75.00%	2	5.56%	6	16.67%	1	3.70%	3.53	0.15
A30	35	25	71.43%	2	5.71%	8	22.86%	0	0.00%	3.49	0.15
A31	32	16	50.00%	5	15.63%	10	31.25%	1	3.70%	3.13	0.18
A33	22	10	45.45%	3	13.64%	7	31.82%	2	7.41%	2.95	0.24
A34	32	13	40.63%	7	21.88%	12	37.50%	0	0.00%	3.03	0.16
A35	34	15	44.12%	8	23.53%	11	32.35%	0	0.00%	3.12	0.15
A36	31	12	38.71%	7	22.58%	11	35.48%	1	3.70%	2.97	0.17
A37	31	8	25.81%	7	22.58%	15	48.39%	1	3.70%	2.71	0.16
A38	30	13	43.33%	6	20.00%	10	33.33%	1	3.70%	3.03	0.18
A39	30	10	33.33%	5	16.67%	13	43.33%	2	7.41%	2.77	0.19
A40	36	15	41.67%	10	27.78%	10	27.78%	1	3.70%	3.08	0.15
A41	19	10	52.63%	4	21.05%	5	26.32%	0	0.00%	3.26	0.21
A42	34	19	55.88%	9	26.47%	6	17.65%	0	0.00%	3.38	0.14
A43	34	16	47.06%	8	23.53%	10	29.41%	0	0.00%	3.18	0.15
A44	34	16	47.06%	7	20.59%	11	32.35%	0	0.00%	3.15	0.16
A45	33	18	54.55%	4	12.12%	11	33.33%	0	0.00%	3.21	0.16
A46	28	12	42.86%	6	21.43%	8	28.57%	2	7.41%	3.00	0.20
A47	24	15	62.50%	4	16.67%	4	16.67%	1	3.70%	3.38	0.19
A48	18	7	38.89%	3	16.67%	6	33.33%	2	7.41%	2.83	0.27
A49	24	9	37.50%	8	33.33%	6	25.00%	1	3.70%	3.04	0.19
A50	30	11	36.67%	7	23.33%	8	26.67%	4	14.81%	2.83	0.20
A51	27	11	40.74%	4	14.81%	9	33.33%	3	11.11%	2.85	0.22
A52	20	7	35.00%	3	15.00%	7	35.00%	3	11.11%	2.70	0.26
A53	30	13	43.33%	8	26.67%	7	23.33%	2	7.41%	3.07	0.18
DUTY-C											
C1	25	12	48.00%	7	28.00%	5	20.00%	1	3.70%	3.20	0.19
C2	18	8	44.44%	6	33.33%	3	16.67%	1	3.70%	3.17	0.22
C3	24	13	54.17%	6	25.00%	5	20.83%	0	0.00%	3.33	0.17
C7	18	11	61.11%	4	22.22%	3	16.67%	0	0.00%	3.44	0.19
C8	22	13	59.09%	4	18.18%	5	22.73%	0	0.00%	3.36	0.18
C12	18	10	55.56%	2	11.11%	6	33.33%	0	0.00%	3.22	0.23
C13	18	9	50.00%	2	11.11%	5	27.78%	2	7.41%	3.00	0.28
C14	21	15	71.43%	3	14.29%	3	14.29%	0	0.00%	3.57	0.17
C15	21	11	52.38%	4	19.05%	6	28.57%	0	0.00%	3.24	0.20
C17	22	10	45.45%	7	31.82%	4	18.18%	1	3.70%	3.18	0.20
C18	25	10	40.00%	4	16.00%	10	40.00%	1	3.70%	2.92	0.20
C19	25	12	48.00%	3	12.00%	9	36.00%	1	3.70%	3.04	0.21
C20	25	12	48.00%	4	16.00%	8	32.00%	1	3.70%	3.08	0.23
C21	26	11	42.31%	5	19.23%	8	30.77%	2	7.41%	2.96	0.21
C22	27	14	51.85%	5	18.52%	7	25.93%	1	3.70%	3.19	0.19

IMPORTANCE OF TASKS FOR JOB ENTRY

DUTY AND TASK	TOTAL NUMBER	ESSENTIAL NO. (4)	ESSENTIAL PERCENT	VERY DESIRABLE NO. (3)	VERY DESIRABLE PERCENT	DESIRABLE NO. (2)	DESIRABLE PERCENT	UNNECESSARY NO. (1)	UNNECESSARY PERCENT	MEAN	STANDARD DEVIATION
DUTY-D											
D1	30	10	33.33%	9	30.00%	10	33.33%	1	3.70%	2.93	0.17
D2	29	7	24.14%	11	37.93%	9	31.03%	2	7.41%	2.79	0.17
D3	33	14	42.42%	7	21.21%	11	33.33%	1	3.70%	3.03	0.17
D4	33	15	45.45%	5	15.15%	12	36.36%	1	3.70%	3.03	0.17
D5	34	15	44.12%	4	11.76%	13	38.24%	2	7.41%	2.94	0.18
D6	34	10	29.41%	6	17.65%	16	47.06%	2	7.41%	2.71	0.17
D7	29	10	34.48%	4	13.79%	14	48.28%	1	3.70%	2.79	0.18
D8	24	9	37.50%	2	8.33%	11	45.83%	2	7.41%	2.75	0.22
D9	23	8	34.78%	2	8.70%	10	43.48%	3	11.11%	2.65	0.24
D10	22	7	31.82%	2	9.09%	12	54.55%	1	3.70%	2.68	0.22
D11	19	5	26.32%	4	21.05%	8	42.11%	2	7.41%	2.63	0.24
D12	19	4	21.05%	1	5.26%	9	47.37%	5	18.52%	2.21	0.26
D13	20	5	25.00%	1	5.00%	10	50.00%	4	14.81%	2.35	0.25
D16	23	6	26.09%	6	26.09%	9	39.13%	2	7.41%	2.70	0.21
DUTY-E											
E1	27	2	7.41%	7	25.93%	11	40.74%	7	25.93%	2.15	0.18
DUTY-F											
F1	36	30	83.33%	5	13.89%	1	2.78%	0	0.00%	3.81	0.08
F2	36	26	72.22%	9	25.00%	1	2.78%	0	0.00%	3.69	0.09
F3	35	25	71.43%	5	14.29%	5	14.29%	0	0.00%	3.57	0.13
F4	32	21	65.63%	6	18.75%	5	15.63%	0	0.00%	3.50	0.14
F5	35	24	68.57%	6	17.14%	5	14.29%	1	3.70%	3.57	0.15
DUTY-G											
G1	30	20	66.67%	3	10.00%	6	20.00%	1	3.70%	3.40	0.17
G2	36	24	66.67%	8	22.22%	4	11.11%	0	0.00%	3.56	0.12
G3	35	21	60.00%	9	25.71%	4	11.43%	1	3.70%	3.43	0.14
G4	29	11	37.93%	9	31.03%	9	31.03%	0	0.00%	3.07	0.16
G5	35	16	45.71%	8	22.86%	10	28.57%	1	3.70%	3.11	0.16
G6	35	13	37.14%	9	25.71%	10	28.57%	1	3.70%	2.86	0.16
DUTY-H											
H1	23	5	21.74%	5	21.74%	11	47.83%	2	7.41%	2.57	0.20
H2	20	8	40.00%	3	15.00%	8	40.00%	1	3.70%	2.90	0.23
H3	35	26	74.29%	2	5.71%	7	20.00%	0	0.00%	3.54	0.14
H4	32	8	25.00%	5	15.63%	19	59.38%	0	0.00%	2.66	0.16
H5	34	22	64.71%	5	14.71%	7	20.59%	0	0.00%	3.44	0.14
H6	33	19	57.58%	5	15.15%	9	27.27%	1	3.70%	3.33	0.17
H7	23	10	43.48%	4	17.39%	7	30.43%	2	7.41%	2.96	0.23
DUTY-I											
I1	28	9	32.14%	1	3.57%	13	46.43%	5	18.52%	2.50	0.22
I2	34	22	64.71%	1	2.94%	11	32.35%	0	0.00%	3.32	0.16
I3	25	6	24.00%	0	0.00%	14	56.00%	5	18.52%	2.28	0.22
I4	27	11	40.74%	1	3.70%	11	40.74%	4	14.81%	2.70	0.23
DUTY-J											
J14	29	18	62.07%	4	13.79%	7	24.14%	0	0.00%	3.38	0.16
J15	29	16	55.17%	5	17.24%	8	27.59%	0	0.00%	3.28	0.17
J16	19	12	63.16%	3	15.79%	5	26.32%	0	0.00%	3.53	0.22

APPENDIX M

RANKING OF TASKS FROM HIGHEST TO LOWEST MEAN IMPORTANCE RATINGS

APPENDIX M

RANKING OF TASKS FROM HIGHEST TO LOWEST MEAN IMPORTANCE RATING

IS THE TASK REQUIRED FOR JOB ENTRY

DUTY AND TASK	TOTAL NUMBER	ESSENTIAL NO. (4)	ESSENTIAL PERCENT	VERY DESIRABLE NO. (3)	VERY DESIRABLE PERCENT	DESIRABLE NO. (2)	DESIRABLE PERCENT	UNNECESSARY NO. (1)	UNNECESSARY PERCENT	MEAN	STANDARD DEVIATION
F1	36	30	83.33%	5	13.89%	1	2.78%	0	0.00%	3.81	0.08
A14	36	29	80.56%	3	8.33%	4	11.11%	0	0.00%	3.69	0.11
F2	36	26	72.22%	9	25.00%	1	2.78%	0	0.00%	3.69	0.09
A8	36	30	83.33%	2	5.56%	3	8.33%	1	2.78%	3.69	0.13
A13	36	28	77.78%	4	11.11%	4	11.11%	0	0.00%	3.67	0.11
A10	33	26	78.79%	3	9.09%	4	12.12%	0	0.00%	3.67	0.12
A22	35	27	77.14%	3	8.57%	5	14.29%	0	0.00%	3.63	0.13
A16	33	24	72.73%	5	15.15%	4	12.12%	0	0.00%	3.61	0.12
A20	36	25	69.44%	7	19.44%	4	11.11%	0	0.00%	3.58	0.12
F5	35	24	68.57%	6	17.14%	5	14.29%	1	3.70%	3.57	0.15
F3	35	25	71.43%	5	14.29%	5	14.29%	0	0.00%	3.57	0.13
C14	21	15	71.43%	3	14.29%	3	14.29%	0	0.00%	3.57	0.17
G2	36	24	66.67%	8	22.22%	4	11.11%	0	0.00%	3.56	0.12
A21	36	26	72.22%	4	11.11%	6	16.67%	0	0.00%	3.56	0.13
H3	35	26	74.29%	2	5.71%	7	20.00%	0	0.00%	3.54	0.14
A29	36	27	75.00%	2	5.56%	6	16.67%	1	3.70%	3.53	0.15
J16	19	12	63.16%	3	15.79%	5	26.32%	0	0.00%	3.53	0.22
A23	35	25	71.43%	3	8.57%	7	20.00%	0	0.00%	3.51	0.14
F4	32	21	65.63%	6	18.75%	5	15.63%	0	0.00%	3.50	0.14
A30	35	25	71.43%	2	5.71%	8	22.86%	0	0.00%	3.49	0.15
A27	36	25	69.44%	3	8.33%	8	22.22%	0	0.00%	3.47	0.14
A19	36	23	63.89%	7	19.44%	6	16.67%	0	0.00%	3.47	0.13
A26	36	25	69.44%	3	8.33%	8	22.22%	0	0.00%	3.47	0.14
C7	18	11	61.11%	4	22.22%	3	16.67%	0	0.00%	3.44	0.19
H5	34	22	64.71%	5	14.71%	7	20.59%	0	0.00%	3.44	0.14
G3	35	21	60.00%	9	25.71%	4	11.43%	1	3.70%	3.43	0.14
A18	33	21	63.64%	5	15.15%	7	21.21%	0	0.00%	3.42	0.15
G1	30	20	66.67%	3	10.00%	6	20.00%	1	3.70%	3.40	0.17
A28	36	23	63.89%	5	13.89%	7	19.44%	1	3.70%	3.39	0.15
A5	26	16	61.54%	4	15.38%	6	23.08%	0	0.00%	3.38	0.17
A42	34	19	55.88%	9	26.47%	6	17.65%	0	0.00%	3.38	0.14
J14	29	18	62.07%	4	13.79%	7	24.14%	0	0.00%	3.38	0.16
A47	24	15	62.50%	4	16.67%	4	16.67%	1	3.70%	3.38	0.19
C8	22	13	59.09%	4	18.18%	5	22.73%	0	0.00%	3.36	0.18
H6	33	19	57.58%	5	15.15%	9	27.27%	1	3.70%	3.33	0.17
C3	24	13	54.17%	6	25.00%	5	20.83%	0	0.00%	3.33	0.17
I2	34	22	64.71%	1	2.94%	11	32.35%	0	0.00%	3.32	0.16
A11	29	17	58.62%	6	20.69%	4	13.79%	2	6.90%	3.31	0.18
A4	28	16	57.14%	6	21.43%	4	14.29%	2	7.14%	3.29	0.19
A9	29	16	55.17%	6	20.69%	6	20.69%	1	3.45%	3.28	0.17
J15	29	16	55.17%	5	17.24%	8	27.59%	0	0.00%	3.28	0.17
A41	19	10	52.63%	4	21.05%	5	26.32%	0	0.00%	3.26	0.21
C15	21	11	52.38%	4	19.05%	6	28.57%	0	0.00%	3.24	0.20
C12	18	10	55.56%	2	11.11%	6	33.33%	0	0.00%	3.22	0.23
A45	33	18	54.55%	4	12.12%	11	33.33%	0	0.00%	3.21	0.16
C1	25	12	48.00%	7	28.00%	5	20.00%	1	3.70%	3.20	0.19
C22	27	14	51.85%	5	18.52%	7	25.93%	1	3.70%	3.19	0.19
C17	22	10	45.45%	7	31.82%	4	18.18%	1	3.70%	3.18	0.20
A43	34	16	47.06%	8	23.53%	10	29.41%	0	0.00%	3.18	0.15
C2	18	8	44.44%	6	33.33%	3	16.67%	1	3.70%	3.17	0.22
A44	34	16	47.06%	7	20.59%	11	32.35%	0	0.00%	3.15	0.16
A31	32	16	50.00%	5	15.63%	10	31.25%	1	3.70%	3.13	0.18
A35	34	15	44.12%	8	23.53%	11	32.35%	0	0.00%	3.12	0.15
G5	35	16	45.71%	8	22.86%	10	28.57%	1	3.70%	3.11	0.16
A25	31	14	45.16%	6	19.35%	11	35.48%	0	0.00%	3.10	0.17
A40	36	15	41.67%	10	27.78%	10	27.78%	1	3.70%	3.08	0.15
C20	25	12	48.00%	4	16.00%	8	32.00%	1	3.70%	3.08	0.20
G4	29	11	37.93%	9	31.03%	9	31.03%	0	0.00%	3.07	0.16
A53	30	13	43.33%	8	26.67%	7	23.33%	2	7.41%	3.07	0.18
A49	24	9	37.50%	8	33.33%	6	25.00%	1	3.70%	3.04	0.19
C19	25	12	48.00%	3	12.00%	9	36.00%	1	3.70%	3.04	0.21
A38	30	13	43.33%	6	20.00%	10	33.33%	1	3.70%	3.03	0.18
A34	32	13	40.63%	7	21.88%	12	37.50%	0	0.00%	3.03	0.16
D3	33	14	42.42%	7	21.21%	11	33.33%	1	3.70%	3.03	0.17
D4	33	15	45.45%	5	15.15%	12	36.36%	1	3.70%	3.03	0.17
A24	29	13	44.83%	6	20.69%	7	24.14%	3	11.11%	3.00	0.20
A46	28	12	42.86%	6	21.43%	8	28.57%	2	7.41%	3.00	0.20
C13	18	9	50.00%	2	11.11%	5	27.78%	2	7.41%	3.00	0.28

APPENDIX M

RANKING OF TASKS FROM HIGHEST TO LOWEST MEAN IMPORTANCE RATING

IS THE TASK REQUIRED FOR JOB ENTRY

DUTY AND TASK	TOTAL NUMBER	ESSENTIAL NO. (4)	ESSENTIAL PERCENT	VERY DESIRABLE NO. (3)	VERY DESIRABLE PERCENT	DESIRABLE NO. (2)	DESIRABLE PERCENT	UNNECESSARY NO. (1)	UNNECESSARY PERCENT	MEAN	STANDARD DEVIATION
A36	31	12	38.71%	7	22.58%	11	35.48%	1	3.70%	2.97	0.17
A12	26	11	42.31%	5	19.23%	8	30.77%	2	7.69%	2.96	0.24
C21	26	11	42.31%	5	19.23%	8	30.77%	2	7.41%	2.96	0.21
H7	23	10	43.48%	4	17.39%	7	30.43%	2	7.41%	2.96	0.23
A33	22	10	45.45%	3	13.64%	7	31.82%	2	7.41%	2.95	0.24
D5	34	15	44.12%	4	11.76%	13	38.24%	2	7.41%	2.94	0.18
D1	30	10	33.33%	9	30.00%	10	33.33%	1	3.70%	2.93	0.17
A15	26	13	50.00%	2	7.69%	7	26.92%	4	15.38%	2.92	0.24
C18	25	10	40.00%	4	16.00%	10	40.00%	1	3.70%	2.92	0.20
H2	20	8	40.00%	3	15.00%	8	40.00%	1	3.70%	2.90	0.23
G6	35	13	37.14%	9	25.71%	10	28.57%	1	3.70%	2.86	0.16
A51	27	11	40.74%	4	14.81%	9	33.33%	3	11.11%	2.85	0.22
A50	30	11	36.67%	7	23.33%	8	26.67%	4	14.81%	2.83	0.20
A48	18	7	38.89%	3	16.67%	6	33.33%	2	7.41%	2.83	0.27
D2	29	7	24.14%	11	37.93%	9	31.03%	2	7.41%	2.79	0.17
D7	29	10	34.48%	4	13.79%	14	48.28%	1	3.70%	2.79	0.18
A39	30	10	33.33%	5	16.67%	13	43.33%	2	7.41%	2.77	0.19
D8	24	9	37.50%	2	8.33%	11	45.83%	2	7.41%	2.75	0.22
A37	31	8	25.81%	7	22.58%	15	48.39%	1	3.70%	2.71	0.16
D6	34	10	29.41%	6	17.65%	16	47.06%	2	7.41%	2.71	0.17
I4	27	11	40.74%	1	3.70%	11	40.74%	4	14.81%	2.70	0.23
A52	20	7	35.00%	3	15.00%	7	35.00%	3	11.11%	2.70	0.26
D16	23	6	26.09%	6	26.09%	9	39.13%	2	7.41%	2.70	0.21
D10	22	7	31.82%	2	9.09%	12	54.55%	1	3.70%	2.68	0.22
H4	32	8	25.00%	5	15.63%	19	59.38%	0	0.00%	2.66	0.16
D9	23	8	34.78%	2	8.70%	10	43.48%	3	11.11%	2.65	0.24
D11	19	5	26.32%	4	21.05%	8	42.11%	2	7.41%	2.63	0.24
A17	25	10	40.00%	2	8.00%	6	24.00%	7	28.00%	2.60	0.26
H1	23	5	21.74%	5	21.74%	11	47.83%	2	7.41%	2.57	0.20
I1	28	9	32.14%	1	3.57%	13	46.43%	5	18.52%	2.50	0.22
A2	19	5	26.32%	1	5.26%	9	46.43%	4	21.05%	2.37	0.26
D13	20	5	25.00%	1	5.00%	10	50.00%	4	14.81%	2.35	0.25
A1	21	5	23.81%	2	9.52%	9	42.86%	5	23.81%	2.33	0.25
I3	25	6	24.00%	0	0.00%	14	56.00%	5	18.52%	2.28	0.22
D12	19	4	21.05%	1	5.26%	9	47.37%	5	18.52%	2.21	0.26
E1	27	2	7.41%	7	25.93%	11	40.74%	7	25.93%	2.15	0.18
A3	19	3	15.79%	0	0.00	12	63.16%	4	21.05%	2.11	0.22

APPENDIX N

RANKING OF TASKS FROM HIGHEST TO LOWEST MEAN FREQUENCY RATINGS

APPENDIX N

RANKING OF TASKS FROM HIGHEST TO LOWEST MEAN FREQUENCY RATING

DUTY AND TASK	TOTAL YES	DAILY (4)	PERCENT	WEEKLY (3)	PERCENT	MONTHLY (2)	PERCENT	LESS THAN MONTHLY (1)	PERCENT	MEAN	STANDARD DEVIATION
F1	36.00	36.00	100.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%	4.00	0.00
F2	36.00	36.00	100.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%	4.00	0.00
A5	26.00	26.00	100.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%	4.00	0.00
A13	36.00	35.00	97.22%	1.00	2.78%	0.00	0.00%	0.00	0.00%	3.97	0.03
A21	36.00	35.00	97.22%	1.00	2.78%	0.00	0.00%	0.00	0.00%	3.97	0.03
A20	36.00	35.00	97.22%	1.00	2.78%	0.00	0.00%	0.00	0.00%	3.97	0.03
A14	36.00	34.00	94.44%	2.00	5.56%	0.00	0.00%	0.00	0.00%	3.94	0.04
A29	36.00	34.00	94.44%	2.00	5.56%	0.00	0.00%	0.00	0.00%	3.94	0.04
A16	33.00	31.00	93.94%	2.00	6.06%	0.00	0.00%	0.00	0.00%	3.94	0.04
J14	29.00	21.00	72.41%	8.00	27.59%	3.00	10.34%	0.00	0.00%	3.93	0.15
A26	36.00	33.00	91.67%	3.00	8.33%	0.00	0.00%	0.00	0.00%	3.92	0.05
A10	33.00	30.00	90.91%	3.00	9.09%	0.00	0.00%	0.00	0.00%	3.91	0.05
A22	35.00	31.00	88.57%	4.00	11.43%	0.00	0.00%	0.00	0.00%	3.89	0.06
F3	35.00	32.00	91.43%	2.00	5.71%	1.00	2.86%	0.00	0.00%	3.89	0.07
I2	34.00	31.00	91.18%	2.00	5.88%	1.00	2.94%	0.00	0.00%	3.88	0.07
A19	36.00	31.00	86.11%	5.00	13.89%	0.00	0.00%	0.00	0.00%	3.86	0.06
A27	36.00	31.00	86.11%	5.00	13.89%	0.00	0.00%	0.00	0.00%	3.86	0.06
A8	36.00	34.00	94.44%	0.00	0.00%	1.00	2.78%	1.00	2.78%	3.86	0.10
A23	35.00	31.00	88.57%	3.00	8.57%	1.00	2.86%	0.00	0.00%	3.86	0.07
A30	35.00	30.00	85.71%	5.00	14.29%	0.00	0.00%	0.00	0.00%	3.86	0.06
A18	33.00	29.00	87.88%	3.00	9.09%	1.00	3.03%	0.00	0.00%	3.85	0.08
C14	21.00	18.00	85.71%	2.00	9.52%	1.00	4.76%	0.00	0.00%	3.81	0.11
A25	31.00	26.00	83.87%	4.00	12.90%	1.00	3.23%	0.00	0.00%	3.81	0.09
H3	35.00	32.00	91.43%	1.00	2.86%	0.00	0.00%	2.00	5.71%	3.80	0.12
A52	20.00	16.00	80.00%	4.00	20.00%	0.00	0.00%	0.00	0.00%	3.80	0.10
A28	36.00	28.00	77.78%	8.00	22.22%	0.00	0.00%	0.00	0.00%	3.78	0.07
C12	18.00	15.00	83.33%	2.00	11.11%	1.00	5.56%	0.00	0.00%	3.78	0.13
C13	18.00	15.00	83.33%	2.00	11.11%	1.00	5.56%	0.00	0.00%	3.78	0.13
F5	35.00	29.00	82.86%	4.00	11.43%	2.00	5.71%	0.00	0.00%	3.77	0.09
G3	35.00	28.00	80.00%	6.00	17.14%	1.00	2.86%	0.00	0.00%	3.77	0.09
A4	28.00	22.00	78.57%	5.00	17.86%	0.00	0.00%	1.00	3.57%	3.71	0.13
C15	21.00	16.00	76.19%	4.00	19.05%	1.00	4.76%	0.00	0.00%	3.71	0.13
A51	27.00	19.00	70.37%	8.00	29.63%	0.00	0.00%	0.00	0.00%	3.70	0.09
G2	36.00	29.00	80.56%	4.00	11.11%	2.00	5.56%	1.00	2.78%	3.69	0.12
D7	29.00	20.00	68.97%	9.00	31.03%	0.00	0.00%	0.00	0.00%	3.69	0.09
F4	32.00	24.00	75.00%	6.00	18.75%	2.00	6.25%	0.00	0.00%	3.69	0.11
C8	22.00	17.00	77.27%	3.00	13.64%	2.00	9.09%	0.00	0.00%	3.68	0.14
H5	34.00	24.00	70.59%	9.00	26.47%	1.00	2.94%	0.00	0.00%	3.68	0.09
A11	29.00	24.00	82.76%	2.00	6.90%	1.00	3.45%	2.00	6.90%	3.66	0.16
A44	34.00	23.00	67.65%	10.00	29.41%	1.00	2.94%	0.00	0.00%	3.65	0.10
D10	22.00	17.00	77.27%	2.00	9.09%	3.00	13.64%	0.00	0.00%	3.64	0.16
J15	29.00	20.00	68.97%	8.00	27.59%	0.00	0.00%	1.00	3.45%	3.62	0.13
A42	34.00	24.00	70.59%	7.00	20.59%	3.00	8.82%	0.00	0.00%	3.62	0.11
D3	33.00	22.00	66.67%	9.00	27.27%	2.00	6.06%	0.00	0.00%	3.61	0.11
A53	30.00	19.00	63.33%	10.00	33.33%	1.00	3.33%	0.00	0.00%	3.60	0.10
G1	30.00	20.00	66.67%	8.00	26.67%	2.00	6.67%	0.00	0.00%	3.60	0.12
C18	25.00	20.00	80.00%	2.00	8.00%	1.00	4.00%	2.00	8.00%	3.60	0.19
A24	29.00	20.00	68.97%	7.00	24.14%	1.00	3.45%	1.00	3.45%	3.59	0.14
A47	24.00	16.00	66.67%	6.00	25.00%	2.00	8.33%	0.00	0.00%	3.58	0.14
H6	33.00	20.00	60.61%	12.00	36.36%	1.00	3.03%	0.00	0.00%	3.58	0.10
A50	30.00	19.00	63.33%	9.00	30.00%	2.00	6.67%	0.00	0.00%	3.57	0.12
C7	18.00	12.00	66.67%	4.00	22.22%	2.00	11.11%	0.00	0.00%	3.56	0.17
C17	22.00	17.00	77.27%	2.00	9.09%	1.00	4.55%	2.00	9.09%	3.55	0.21
H4	32.00	21.00	65.63%	9.00	28.13%	0.00	0.00%	2.00	6.25%	3.53	0.14
D9	23.00	16.00	69.57%	4.00	17.39%	2.00	8.70%	1.00	4.35%	3.52	0.18
C19	25.00	19.00	76.00%	3.00	12.00%	0.00	0.00%	3.00	12.00%	3.52	0.21
D4	33.00	19.00	57.58%	12.00	36.36%	2.00	6.06%	0.00	0.00%	3.52	0.11
A40	36.00	22.00	61.11%	11.00	30.56%	2.00	5.56%	1.00	2.78%	3.50	0.12
D6	34.00	19.00	55.88%	13.00	38.24%	2.00	5.88%	0.00	0.00%	3.50	0.11
A43	34.00	20.00	58.82%	11.00	32.35%	3.00	8.82%	0.00	0.00%	3.50	0.12

RANKING OF TASKS FROM HIGHEST TO LOWEST MEAN FREQUENCY RATING

DUTY AND TASK	TOTAL YES	DAILY (4)	PERCENT	WEEKLY (3)	PERCENT	MONTHLY (2)	PERCENT	LESS THAN MONTHLY (1)	PERCENT	MEAN	STANDARD DEVIATION
C20	25.00	17.00	68.00%	5.00	20.00%	1.00	4.00%	2.00	8.00%	3.48	0.19
D11	19.00	15.00	78.95%	1.00	5.26%	0.00	0.00%	3.00	15.79%	3.47	0.27
D5	34.00	19.00	55.88%	12.00	35.29%	3.00	8.82%	0.00	0.00%	3.47	0.12
G5	35.00	22.00	62.86%	10.00	28.57%	0.00	0.00%	3.00	8.57%	3.46	0.15
C22	27.00	18.00	66.67%	5.00	18.52%	2.00	7.41%	2.00	7.41%	3.44	0.18
D16	23.00	16.00	69.57%	3.00	13.04%	2.00	8.70%	2.00	8.70%	3.43	0.21
A45	33.00	20.00	60.61%	9.00	27.27%	2.00	6.06%	2.00	6.06%	3.42	0.15
I4	27.00	19.00	70.37%	2.00	7.41%	4.00	14.81%	2.00	7.41%	3.41	0.20
D1	30.00	17.00	56.67%	8.00	26.67%	5.00	16.67%	0.00	0.00%	3.40	0.14
A41	19.00	10.00	52.63%	7.00	36.84%	1.00	5.26%	1.00	5.26%	3.37	0.20
H7	23.00	14.00	60.87%	5.00	21.74%	2.00	8.70%	2.00	8.70%	3.35	0.21
A9	29.00	18.00	62.07%	5.00	17.24%	4.00	13.79%	2.00	6.90%	3.34	0.18
G6	33.00	18.00	54.55%	11.00	33.33%	1.00	3.03%	3.00	9.09%	3.33	0.16
A38	30.00	18.00	60.00%	7.00	23.33%	2.00	6.67%	3.00	10.00%	3.33	0.18
C3	24.00	10.00	41.67%	12.00	50.00%	2.00	8.33%	0.00	0.00%	3.33	0.13
C2	18.00	9.00	50.00%	6.00	33.33%	3.00	16.67%	0.00	0.00%	3.33	0.19
A46	28.00	17.00	60.71%	6.00	21.43%	2.00	7.14%	3.00	10.71%	3.32	0.20
A17	25.00	15.00	60.00%	4.00	16.00%	5.00	20.00%	1.00	4.00%	3.32	0.19
D2	29.00	14.00	48.28%	11.00	37.93%	3.00	10.34%	1.00	3.45%	3.31	0.15
D8	24.00	13.00	54.17%	6.00	25.00%	4.00	16.67%	1.00	4.17%	3.29	0.19
I1	28.00	14.00	50.00%	8.00	28.57%	6.00	21.43%	0.00	0.00%	3.29	0.16
A12	26.00	16.00	61.54%	4.00	15.38%	3.00	11.54%	3.00	11.54%	3.27	0.22
J16	19.00	11.00	57.89%	4.00	21.05%	2.00	10.53%	2.00	10.53%	3.26	0.25
A31	32.00	18.00	56.25%	7.00	21.88%	4.00	12.50%	3.00	9.38%	3.25	0.18
I3	25.00	14.00	56.00%	4.00	16.00%	6.00	24.00%	1.00	4.00%	3.24	0.20
A49	24.00	10.00	41.67%	10.00	41.67%	3.00	12.50%	1.00	4.17%	3.21	0.17
A35	34.00	15.00	44.12%	13.00	38.24%	4.00	11.76%	2.00	5.88%	3.21	0.15
A34	32.00	12.00	37.50%	15.00	46.88%	4.00	12.50%	1.00	3.13%	3.19	0.14
A15	26.00	14.00	53.85%	5.00	19.23%	4.00	15.38%	3.00	11.54%	3.15	0.22
G4	29.00	11.00	37.93%	12.00	41.38%	5.00	17.24%	1.00	3.45%	3.14	0.16
A33	22.00	10.00	45.45%	8.00	36.36%	1.00	4.55%	3.00	13.64%	3.14	0.23
C1	25.00	10.00	40.00%	9.00	36.00%	5.00	20.00%	1.00	4.00%	3.12	0.18
HI	23.00	10.00	43.48%	7.00	30.43%	3.00	13.04%	3.00	13.04%	3.04	0.23
C21	26.00	15.00	57.69%	3.00	11.54%	2.00	7.69%	6.00	23.08%	3.04	0.26
A36	31.00	14.00	45.16%	8.00	25.81%	4.00	12.90%	5.00	16.13%	3.00	0.21
A48	18.00	5.00	27.78%	9.00	50.00%	3.00	16.67%	1.00	5.56%	3.00	0.21
A1	21.00	8.00	38.10%	7.00	33.33%	1.00	4.76%	5.00	23.81%	2.86	0.27
H2	20.00	7.00	35.00%	6.00	30.00%	4.00	20.00%	3.00	15.00%	2.85	0.25
A39	30.00	11.00	36.67%	9.00	30.00%	4.00	13.33%	6.00	20.00%	2.83	0.22
A3	19.00	7.00	36.84%	4.00	21.05%	4.00	21.05%	4.00	21.05%	2.74	0.28
A37	31.00	9.00	29.03%	10.00	32.26%	6.00	19.35%	6.00	19.35%	2.71	0.20
D13	20.00	6.00	30.00%	5.00	25.00%	6.00	30.00%	3.00	15.00%	2.70	0.25
A2	19.00	7.00	36.84%	2.00	10.53%	6.00	31.58%	4.00	21.05%	2.63	0.29
D12	19.00	4.00	21.05%	6.00	31.58%	5.00	26.32%	4.00	21.05%	2.53	0.26
E1	27.00	4.00	14.81%	8.00	29.63%	10.00	37.04%	5.00	18.52%	2.41	0.24

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