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ABSTRACT

The problem of time-shortening the first year of the apprenticeship training program now on-going in the tool, die and precision machining industry is addressed. A research study was carried out comparing apprentices in on-going programs with apprentices in a newly designed programed course of instruction. The results, which are discussed in detail, indicated that: 1) The learning time necessary to acquire and demonstrate competency and capability requirements for selected tasks per machine is shorter than that recommended by present National Tool, Die and Precision Machining Association/Bureau of Apprenticeship and Training (NTDPMA/BAT) standards and, 2) Total machine-time allocations as now specified are not true indicators of learning time. The results show that the assumption that meeting NTDPMA/BAT recommended time-machine standards can be regarded as equivalent to satisfactory completion of first year apprenticeship requirements cannot be substantiated. Appendixes include several relevant forms, research data, and a 25-item bibliography. (Author/DS)

A STUDY OF ACCELERATED ON-THE-JOB TRAINING PROGRAM FOR THE FIRST YEAR OF ON-THE-JOB TRAINING FOR THE PRECISION MACHINIST APPRENTICE

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1) The learning time necessary to accomplish criterially defined time-machine tasks is shorter than that recommended by present NTDPMA/BAT standards and,
2) Total machine-time allocations as now specified are not true indicators of learning-demonstration time.

The conclusion that meeting present NTDPMA/BAT recommended time-machine standards is equivalent to satisfactory completion of first year apprenticeship requirements is disproved.

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OVERVIEW AND HIGHLIGHTS OF MAJOR FINDINGS AND CONCLUSIONS

This research study was designed to evaluate the present time-machine criteria applicable to the first year of apprenticeship in the tool, die and precision machining industry. The specific learning time and the time-dimension inherent in the research program design were compared to the current "standards", in an attempt to respond to the following hypotheses:

1) The present hours per machine criteria for the conduct of the first year of apprenticeship is not a valid indicator of learning time.

2) The length of time required to acquire and demonstrate the skills and knowledge determined by the industry to be necessary for the first year apprenticeship is less than the total time now recommended.

Two groups of students, randomly selected and matched, were obtained from the graduates of the NTDPMA national pre-employment training program. These students provided data from their first year of apprenticeship for comparison with the existing time-machine "standard".

The students from Group I provided data in the form of time required to achieve predetermined performance criteria, following a programmed, industry-generated, curriculum. This curriculum for the first year of apprenticeship spanned the four basic machines (drill, mill, lathe, grinder), and was based on a specific sequence, content, and measurable variety of tasks.

The Group II students, utilizing a similar task/machine recording form, indicated time spent on a given task, following the same apprenticeship process as presently exists in the industry. This group did not follow any predetermined curriculum. The on-going programs established measures of capability were used for this group.

Reports were obtained from both groups on a two-month basis. The resultant data from these groups indicated a significant difference between learning time per task and (1) the present model standards and hours per machine, and (2) the total hours per task indicated by the second apprentice group. When coupled with a 1971 case study of a typical apprentice group, which showed lack of adherence to the present model "standards", it would appear that time beyond that required for learning is being spent by an apprentice on a given task. The results of the study indicated that the performance level of the first year apprentice, as determined by the tool and die industry, can be achieved in much less time than the present standards permit.

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LIST OF ABBREVIATIONS AND SYMBOLS

BAT	Bureau of Apprenticeship and Training
BES	Bureau of Employment Security
MDT(A)	Manpower Development Training (Act)
NTDPMA	National Tool, Die and Precision Machining Association
OJT	On-the-Job Training
RPM	Revolutions Per Minute
SPARS	Student Practical Application Rating System

CHAPTER I

INTRODUCTION

The tool, die and precision machining industry, of which the National Tool, Die and Precision Machining Association (NTDPMA) is an integral part, is comprised of those independent contracting tool, die and precision machining companies who service the major manufacturing industries such as automotive, aerospace, electronics, etc. These companies are, generally, privately owned and operated and range in labor force size from ten to 250 craftsmen.

The NTDPMA was formed in 1943 in order to secure federal recognition for this segment of the tooling industry. Since that time the NTDPMA has grown from 40 to 1,600 member-companies located, primarily, in the highly industrialized states throughout the nation. Throughout its history, the NTDPMA has been active in such areas as: business management; industrial safety; marketing and public relations; pertinent business and trade information retrieval and dissemination; serving as consultant to Government in matters concerned within its segment of the tooling industry; and conducting and operating apprenticeship training programs for the tool and die industry.

A. History of NTDPMA Apprenticeship Programs

Since the earliest recorded history of man, apprenticeship has been a process whereby a knowledgeable and proficient craftsman indoctrinated a novice in the knowledges and skills requirements and practices of his particular trade. Traditionally, the primary learning process was imitative-based during the acquisition of the requisite demeanor and abilities of the trade from the artisan conducting the training.

This concept and inherent processes were brought by the European craftsmen to this country during its early founding and subsequent growth. However, the evolutionary process of national growth dynamics over ensuing generations has produced significant changes in both the processes and content of apprenticeship training. No longer is the apprentice legally bound to one "master". Also, he is paid according to some designated format or guideline which binds his employer to the content of the apprenticeship training as well as to the process. At the completion of his apprenticeship training, the student-apprentice usually receives a diploma or certificate which denotes his achievements, at which time he is accorded the title of Journeyman.

Promoted to a great extent by the pressures of industry itself, the Federal Committee on Apprenticeship was formed in 1934. This was a committee organized in order to establish national policy and guidelines for apprenticeship training.

This was followed in 1937 by the National Apprenticeship Law, the purpose of which was:

> "to promote the furtherance of labor standards of apprenticeship ... to extend the application of such standards by encouraging the inclusion thereof in contracts of apprenticeship, to bring together employers and labor for the formulation of programs of apprenticeship, to cooperate with State agencies in the formulation of standards of apprenticeship."*

To implement this law, and to coordinate the recommendations of the Federal Committee on Apprenticeship, the Bureau of Apprenticeship and Training (BAT) was created as a part of the Department of Labor in 1937.

Since its incept, the BAT has been the Federal Agency which has functioned in a unificational capacity and provided guidelines for the implementation of apprenticeship programs for approximately 350 occupations. Their assistance was invaluable to NTDPMA in establishing Apprenticeship Guidelines and Standards for the tool and die industry. Their contribution to the development of the NTDPMA Pre-Employment Training Program, funded by the MDTA, cannot be minimized.

The effect of expanding technology on the tool, die and precision machining industry increased the complexity of work-type and the related operations. Concomitantly, the machinery and tools necessary to respond to the changing work type and kind increased in complexity and scope of capability. These consequents affected the employment needs of this industrial community by focusing attention on the need for a constant availability of an adequately educated and trained labor supply.

Within the tool, die and precision machining industry, early attempts at implementing training programs at the local level were characterized by operational intermittency, and inadequate utilization of evolving pertinent processes and content in the training course learning experiences. Many times the apprentices were taught only the rudiments of the occupation, as training was viewed as something to be done quickly and minimally. Related course content information was introduced on an ad-hoc basis as specific situations evolved and was not programmed into the instructional course in any sense.

The economic boom period from the 1950's to 1960's caused many young men, who desired to enter the machine trades, to be attracted to the larger companies instead of the more general and smaller machine trades segment.

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*U.S. Department of Labor, Manpower Administration, Apprenticeship Past and Present, Washington, D.C., 1969.

This was a result of both the small company "job-shop image" versus a "corporate image" and the fact that the larger companies offered training in various elements of all machine trades, including tool, die and precision machining for their own "captive" or internal divisions.

Added to this differentiation of image and work-mobility factors were: the recognized superior training programs and immediate "titling", occupational ladders; and the generally accepted stability/security of corporate enterprise versus a contract job-shop. These factors caused serious recruitment, acquisition, training, and retention problems for the independent segment of the tool, die and precision machining industry. The need for maintaining an adequate and available labor supply within this industrial segment plus the tenets of the Federal Manpower Policy provided the initial impetus for the present NTDPMA-MDT Pre-Employment Training Program and the OJT Apprenticeship Program.

In 1962, with enactment of the Manpower Development and Training Act (MDTA), this industrial segment was provided financial aid necessary to attenuate the above influences within the trade and to address government manpower policy tenets, as they were applicable to the trades labor force expansion and composition. Prior to 1962, the small company owner was forced to rely on the product of the vocational school, whose training had often been accomplished with little dialogue between education and industry.

When the newly-designed NTDPMA Apprenticeship Training Program was implemented in 1964, it was determined by the Apprenticeship and Training Committee of the NTDPMA that a three-month (12-week) program would provide the industry with an apprentice who would have sufficient knowledge and introductory (basic) skills to be of immediate value to the trade. In addition, this level of knowledge would provide a logical base from which to build additional capability and competency during the apprenticeship period.

It was felt that, given a student with good potential and interest, coupled with a high school education as a foundation, this length of intensive training would produce a worker with rudimentary knowledge and skill on the four basic machines (drill, mill, lathe, grinder). There were no demographic or experiential constraints affecting the selection of trainees. Therefore, it was possible to attract students of reasonably high educational achievement and potential. Their achievement during the 12-week Pre-Employment Training Program far exceeded the untrained "walk-in" when it came to competition for the same job.

As the success of the program became apparent, reflected by a completion and placement rate of better than 75%, additional MDTA contracts followed in 1964, 1966, 1967, 1969, 1971 and 1973. In keeping with the change in national manpower policy concerning training of the disadvantaged and those with low educational skills, the requirement for entrance into the NTDPMA Apprenticeship Training Program was lowered from high school graduate level to 7th Grade completion level. Along with this, the 12-week program was expanded to 16 weeks, and incorporated the NTDPMA Starter Series books. These were designed to provide awareness, orientation and foundation training in basic related educational skills, such as shop mathematics and principles of blueprint reading.

Presently 16 weeks in duration, the current Pre-Employment Training Program is now structured to provide the students with the rudiments of basic machine operation; related technical skills; and knowledges which can be marketed in today's industrial society.

Funded under the Manpower Development Training Act (MDTA), this program now has guidelines and constraints relative to the selection of participants for training. First, all candidates are screened by the Bureau of Employment Security (BES), using the General Aptitude Test Battery and applicable machinist norms. Second, those candidates who achieve the minimum acceptable scores and who have the minimum stipulated education, (now raised to 10th Grade or equivalent to more readily conform to requirements for indentureship) are referred to NTDPMA representatives for final selection. While final determination of the students is the prerogative of the local NTDPMA selection committee, and is usually based on personal interviews, it should be remembered that Government policy dictates that prime consideration be given to disadvantaged and Viet-Nam veterans.

B. Description of Program

The pre-employment curriculum is divided into two phases; Phase I, the work-sampling phase, which consists of four weeks; and, Phase II, the pre-trades training phase, which consists of 12 weeks.

Phase I, Work-Sampling Phase -- four weeks duration. During this period, trainees are exposed to the nature of the machining industry. Special texts have been prepared, special films and projectors are utilized and "threshold" training materials (simplified and miniaturized lathes and milling machines) are used to take the student through the awareness and orientation phases. These materials have been well validated in previous training projects. In cases where performance testing indicated a need, the instructor-trainee ratio was improved so trainees received a more complete and intensive exposure to the nature of the trade during this four-week period. The training hours during the four-week period are spent as follows: three hours per day working classroom exercises from the course texts under the full supervision of instructors and four hours per day of supervised operation on the basic machines. This means a seven-hour school day, five days a week for four weeks.

Phase II, Pre-Trades Training Phase -- 12 weeks duration. During this period, the trainees move upward to more traditional materials. The text books used in this phase discuss detailed machine shop theory, mathematics and blueprint reading. This set of texts is now one of the most widely used packages in machine-trades training in the United States. Use of these materials and proven methods of instruction quickly move the trainee into an area of basic pre-employment knowledge. In addition, as the trainee progresses in the Pre-Employment Program, he moves up to work on full-size modern machines wherein the basic set-up and operation of each of the four families of major machines -- Lathes, Drills, Millers and Grinders is learned. The training hours are divided the same as in Phase I: three hours of classroom-type work, four hours of machine work.

Throughout the total training period concerned by this research study, NTDPMA field staff (Regional Administrators) were constantly in contact with the instructors and students, keeping apprised of the progress of each student in the training program. Toward the end of the 16-week period, these Regional Administrators contacted tool and die companies in the immediate geographical area and secured job interviews for the students. During that period, the Regional Administrator functioned as a counselor to the student, ascertaining the attitudes, desires and needs of the student. Working closely with the instructor of the training program, he was able to obtain a profile of the student's abilities and weaknesses. Every attempt was made to ensure positive employer/employee relations by "matching" the graduate to the company; i.e. students who grasp new concepts rapidly should function well in a company whose activity is highly diversified while the student who takes longer to grasp new concepts, requiring more repetitive work than others to solidify the learning process could find a company with a certain degree of production work to be a more desirable working environment.

Once established in training-related jobs, the students were subsequently "indentured" for a four-year period in a State or BAT approved OJT program. Indenturing involved establishing a set of Apprenticeship Training Program Standards and Guidelines which reflected the amount of hours per machine which the employer would work the apprentice (see Appendix A). Upon concurrence by the State or Bureau of Apprenticeship and Training that (1) the Standards are acceptable, and (2) that the company has appropriate facilities to implement the Standards, the apprentice signed indenturing papers which formally registered him in an approved program leading to Journeyman status. He was then required to log his total work time over the four years on all machines in a formal record book which was verified periodically by his supervisor. It was by this record that verification of compliance to the Standards was determined (see Appendix B).

Additionally, the student-apprentice was required to take 144 hours per year of related classroom instruction. This was usually acquired in evening school one or two nights a week at a State approved training facility. This study was in such subject areas as geometry, metallurgy and blueprint reading.

The basic research design did not consider it necessary to change the present 16-week Pre-Employment Training Program previously described.

The present program processes, content and objectives have remained, to a great extent, constant over the past five years and have produced a product acceptable to the tool and die industry. While prior to this research program, little or no attempt had been made to measure the knowledges and skills of a pre-employment training program graduate, the industrial reaction to the new apprentices who had been placed in NTDPMA member shops had been decidedly positive. This fact, coupled with the timing of the research contract, starting subsequent to the MDTA training programs contract then being implemented, resulted in the determination not to alter the Pre-Employment Program.

During this pre-employment training, all students were assessed by a variety of instruments to obtain demographic, educational, and performance data for future evaluation. These instruments incorporated both objective and subjective evaluations of both manual dexterity and knowledge acquisition. In addition, subjective evaluations of the students were provided by their program instructors.

Upon acceptance into the training program, each student completed a Student Information Form which provided demographic and educational information (see Appendix C). Prior associated experience, prior associated training, level of education, military and marital status, etc. were noted for potential correlation and/or usefulness with subsequent performance.

Two objective tests were utilized during the pre-employment training. The first of these, the First Year Technical Proficiency Test, designed by NTDPMA, was constructed to evaluate the knowledge of the first-year apprentice in OJT and related training. This two-part test is divided into 12 sections, each concerned with a specific area of knowledge which the students should possess. Each section is comprised of 20 questions which are to be answered within a time limitation (see Appendix A). This test was administered three times during the pre-employment training period: at the time of entry, at mid-term, and at the end of the training period. This provided a measurement of learning and, discretely, rate of learning, by comparing entry level with intermediate and final levels of knowledge and skills. The shift in emphasis during this training phase from classroom to machine operation made the eighth week a logical testing point.

The second test, the Mechanical Comprehension Test, was designed to measure the ability to perceive and understand the relationship of physical forces and mechanical elements in practical situations (see Appendix A). This test was administered three times in the pre-employment training program, at the entry level, at mid-term, and at the completion of the 16-week pre-employment program. Again, it was possible to note any change in learning/performance over the full-term training period.

Subjective evaluations of the students were also obtained during this pre-employment training period from the course instructors. Their expertise, based on years of training in this particular environment qualified them to conduct bi-modal levels of evaluation; one as to actual ability while running machines, the other in reference to general attitude and potential value to the industry.

The primary evaluation level was in the form of the Student Practical Application Rating System (SPARS). (See Appendix D). This form was completed by the pre-employment instructor during the last week of the training program. Each of the students was graded on a one to five scale in the areas of proficiency and learning speed for each of the basic machines (Lathe, Cylindrical Grinder, Surface Grinder, Mill, Drill) and Inspection. A maximum attainable score in each of the two categories was 30. While this was a subjective evaluation, it nevertheless provided an insight as to the ability of the student to function in the simulated working on-the-job environment.

The second subjective evaluation level is in the form of the Employee Performance Evaluation Form. This form was originally developed by NTDPMA to assist employers in rating employees for the purpose of rewarding performance (see Appendix E). This form was completed by the instructor at the end of the training period. Basically, the form is comprised of seven factors including Accuracy, Quantity, Adaptability, Dependability, Attendance, Knowledge, and Attitude. Each of these seven factors has five descriptive phrases which reflect characteristics pertinent to the factor. The instructor was directed to indicate the phrase which best described the characteristic of the student for that particular factor. These phrases in turn are assigned a point value. If a student was rated the maximum in each factor area, the total grade was 100. Point emphasis was placed on the areas deemed most valuable by the industry, namely, accuracy, quantity, adaptability and job knowledge.

Finally, the individual program Class Test Report, reflecting student knowledge in the areas of blueprint reading and mathematics, was completed by the pre-employment instructor at the 8th and 16th week of the pre-employment training program. This provided a general frame of reference as to the ability of the individual student when compared with the rest of the class (see Appendix F). The applicability of the report was limited because the tests which were used to determine knowledge were to a great extent the product of the individual instructor and therefore were not uniform between various pre-employment programs. However, the uniformity of subject matter to a degree compensated for this, and the tests did provide an indication of ability as defined by the expertise of the instructor, and where one instructor taught several classes, the scope of relativity was proportionally increased.

Thus, for comparative evaluation, the pre-employment program provided a comprehensive profile on all students who completed the training. Their background, education, knowledge, and performance under simulated working conditions were recorded for comparison within the total pre-employment group and also for reference and comparison with on-job-training performance.

While a complete battery of data is not available on those students who did not complete the pre-employment training program, due to the chronologically constrained points in training during which the data was acquired, specific background, experiential, and entry level information is available for all students. It was felt that any information which could conceivably characterize these students who drop out would be valuable when addressing the problem of student selection for the tool, die and precision machining apprenticeship programs.

CHAPTER II

PRESENT STATE OF KNOWLEDGE

A. Review of the Literature

From the general literature review, those major studies concerned directly or peripherally with time-machine-task relationships were intensively reviewed for impact on and import to the research study to be undertaken.

Four studies were selected as having prescriptive value as well as providing a construction baseline for the process and content of the time-machine-task problem concern of the research study; and the inherent sub-problem -- the effects and affects of time-shortening the NTDPMA Apprenticeship Training Program.

Time-shortening possibilities are suggested by Barroci (1973) by the utilization of a modular, systematic approach to apprenticeship programs. The modular approach recognizes individual learning rates for certain content acquisition. The systematic provisions are "building blocks" of various and selected levels of content from basic to multi-level. The acquisition of knowledge and skills above basic content is to be programmed as a function of necessity and/or desire. The time relationship is a "floating" constraint, and in this position, it is a function of the learner, more nearly, and is not beyond reasons prescriptive. In this manner, time is flexible and allows program rigidity to be viewed more idiosyncratically, by needs and competencies.

The time dimension also appears in a survey-study accomplished by Drew (1969). While not speaking of time-compression, per se, the study indicates that time cannot be held to be truly indicative of task learning. This view is taken, mainly, due to the interruption of the apprenticeship course programming by the necessity for meeting production requirements. A major inference of this study is that time is "stretched" by non-conformance to programmed apprenticeship training schedule. This being the case, the time recorded is total time spent in a program and not , necessarily, learning time.

Horowitz and Herrnstadt (1969) delineated and examined paths by which apprentices ultimately became journeymen. This study-survey included the times that tool and die journeymen estimated and times they actually spent in obtaining this "Journeyman competence". The study identified the four (4) basic families of machines: Drill, Lathe, Milling Machine and Surface Grinder as those machines which most respondents thought were basic to and highly utilitarian in the trade. The study pointed out that it took less time to produce all-round tool and die makers by programmed structures than unprogrammed and/or random methods. Again, time in a program versus learning time and/or time to accrue "competency" was too much a variable to be definitized to a limit. This was primarily due to lack of program structure and content uniformity and criteria. The times necessary to become a "competent" tool and die maker ranged from nine to 11 years. The respondents felt that the national tool and die standards were too low for the basic machines -- on a training time basis -- considering the high utility of the basic machines during the total time estimated to become competent journeymen.

Time, in this sense, shifted from criterial-standard based time to individualistically inputed competency-based time. However, one-half of the respondents felt that time could be shortened during the "training" period if a programmed schedule of tasks was adhered to.

The specific comparative evaluative-survey which addressed time-shortening of apprenticeship training programs, without decreasing competence, was accomplished by Rigby and Eiffert (1971). The postulate of the time-shortened training period efficacy was reviewed by various journeymen as well as other trade personnel. The general consensus was, the time could be shortened without compromising competency if a valid program structure was adhered to.

The major conclusions reached were: (1) total time as specified by typical training programs is not as important as how the time was spent; (2) graduation from on-going typical apprenticeship training programs is based on time in the program rather than by competency demonstration; and (3) there is lack of criterial attribute consistency and compatibility between the various companies who execute the OJT segment of apprenticeship programs.

In all of the studies concerned, which have direct or related import concerning the purpose and design of the proposed NTDPMA research study, the factor of time is the common referrent. This is exemplified by the direct time relationship of the Rigby and Eiffert (1971) study or the second and third order time relationships posited in the other studies mentioned. The identification of the four (4) basic machines from the Horowitz and Herrnstadt study and the apprenticeship course programming versus efficiency and competency time frames from Barroci (1971) and Drew (1969); have helped prescribe the format and structure of the NTDPMA research study contained herein determination of learning time per (programmed) machine task and as this affects time-shortening in NTDPMA Apprenticeship Training Programs.

B. <u>Statement of the Problem</u>

During the conduct of the NTDPMA Apprenticeship Training Programs, the operational feedback from the membership of the NTDPMA, and the interfacing government agencies, as well as the students, are analyzed and evaluated. The rationale for on-going assessment/evaluation is to provide a program corrective feedback information channel for reasons of training program content and processes up-date.

The present-day major concerns that have appeared most frequently during these assessments are: (1) the reasons for student drop-outs (either during pre-employment training phase or at later OJT phase); (2) the meaning of "Journeyman" in requisite time, knowledge and capability terms; (3) inability of present program processes and content to be utilized in the service of idiosyncratic student learning needs; (4) the random and/or deliberate assignment of apprentices to long-term operation of (only) certain machines in "violation" of recommended standards and the lack of adequate data about the effects of this action; and, (5) the affects of non-uniformity of machine-time/task versus the guideline standard time-task relationships.

There is one property which threads through all of the aforementioned problems and problem areas. That is, that property concerning the validity and acceptance of the NTDPMA/BAT recommended guidelines-standards; the time-tasks per machine related to the progressive achievement of Journeyman status.

An inspection of apprentices' log books, backed up by informal surveys within the trade, reveals that a general standard of a "reasonable amount of time performing a basic number of tasks" applies, at least equally well in practice, in allowing assignment of the title Journeyman as does compliance with the total and rigorous 8,000-hour program recommended by NTDPMA/BAT.

The time-machine-task dimension being the general problem area base, examined in view of the variance of documented time-machine-task versus apprentice progression appearing consistently, a research study was made into the time-machine-task program segment. This was accomplished in order to determine the degree of validity of the NTDPMA/BAT recommended guideline standard versus expected and acceptable apprentice capability.

Due to the constraints of money and time, and in order to take advance of a newly started apprenticeship training program, the study was delimited to consider only the first year of the NTDPMA Program.

C. Hypotheses

The dimension of time, as it is described and utilized in typical tool, die and precision machining apprenticeship training programs, is the most significant parameter recommeded for further research effort. The findings and recommendations of formal research studies, as well as the supporting results of prior conducted NTDPMA apprenticeship training programs, identify time as the common relational element, primarily or secondarily, in each general problem area delineated (see Statement of Problem and Review of the Literature).

This research study investigated the component parts of the time dimension, namely: learning time discretely; and, time relationships to first year capability and competency "standards". This information will be useful within the tool, die and precision machining training programs area, for purposes of: (1) identification of the discrete learning time (task-per-machine) and the relationship of the learning time to the total time recommended per machine as now delineated; and (2) examination of the validity of apprenticeship training program efficiency and utility measures when learning time rather than recommended total time is used as the time dimension factor in the computations.

D. Research Hypotheses

This specific research study was designed to investigate the learning time differentiation from total time and its meaning for use in the design of apprentice training programs by postulating and answering to the following General Hypotheses:

1. The recommended total time per machine -- now forming the time constraint for the design and conduct of the first year of a typical NTDPMA apprenticeship training program -- is not a true indicator of learning time.

2. The learning time necessary to acquire and demonstrate competency and capability requirements for selected tasks per machine -- determined by the industry to be expected of (an average) first year apprentice -- is shorter than the total time recommended.

CHAPTER III

PROJECT DESIGN

A. Survey Instruments

Group I

The shop owners involved in the research study agreed to move apprentices in Group I "as rapidly as possible" from task to task, once learning had been accomplished, and to determine learning time and record it. Recording forms were provided to each student in Group I (see Appendix G). The definition of learning time (time required to perform a task three times to a specified minimum criterion) was explained. This was also reviewed with the company evaluator in charge of the apprentice. It was explained that the evaluator, in his determination of whether a given sub-task had been performed should follow the rule of reason. For example, if it took days to perform a task which ordinarily should take a half-hour, the apprentice was not judged to have met the performance criterion. (To meet the existing requirements of apprenticeship program standards, the total time spent by apprentices in Group I on various machines was logged in their own records, but was not treated as relevant data for the purpose of the present study).

The recording form, along with indicating the applicable hours per task, also provided data as to associated processes accomplished by the apprentice for each task. These processes included, among others, setting up the machine, the selection of cutting tools, and the inspection of the product. In addition, the reporting form required shop instructors to initial the data contained on the form, indicating cognizance and verification of the data contained therein. These forms were then obtained from the Group I students, by the Regional Administrators on a two-month basis.

Group II

This group of apprentices functioned as a reflection of apprenticeship as it is currently being practiced. These apprentices were provided with a reporting form similar to that utilized by Group I (see Appendix H) but recorded total time spent on a given task. The apprentices were moved from task to task according to the dictates of the employer, and the duration of time which was spent on each task was determined by the employer. No attempt was made to influence his opinion of how to train the apprentice, either in duration of task time or scope of tasks.

The monitoring of these students, by both Regional Administrators and instructors, was the same as for Group I. The context of the reporting forms used by this group was identical to that used by Group I, except that they recorded total time per task, not learning time.

B. Profile of Research Apprentices

The pre-employment training programs from which students were selected contained a total of approximately 700 students. A list of specific training locations is provided in Appendix I.

These training locations generally are concentrated in highly industrialized geographical areas across the nation. By way of illustrating the geographical dispersion of the student population under consideration, it should be noted that 14 training programs (280 students) were sampled from the East Coast. These programs were located in New York State, Pennsylvania, Massachusetts and New Jersey. In the Mid-West, 10 programs containing 200 pre-employment program students were sampled. These programs were located in the States of Ohio, Michigan and Illinois. In the south, five programs containing 100 students were sampled. These programs were located in Tennessee, Arkansas, and Texas. In the West, eight programs containing 160 students were sampled. These programs were in the States of California and Colorado.

The basic research design provided for the selection of 150 apprentices (the contract had stipulated 120), distributed into two groups of equal size. Each of the 75 students in Group I, who had been selected on a random sample basis, was matched with another student in Group II from the same on-going pre-employment programs. The selection process itself was accomplished during the fourteenth week of a given training program, due to programatical constraints of placing students in the industry.

The criteria used for student matching were scores on the First Year Technical Proficiency Test and the Mechanical Comprehension Test, as well as previous associated training, previous associated experience, age, military and marital status, membership in a disadvantaged group, and level of general education. A profile of the two groups of students is contained in Appendix J.

C. Basic OJT Research Design

In essence, the research design is in the form of a comparative-study and not a pure-experimental design. The comparative-study research design was determined to be a prior and necessary step before execution of a pure-experimental design, as an attempt is being made to find out where this total program is -- assumedly offering an acceptable product, but not measured -- before recommending changes. This study, in this form, more nearly serves the total interests of all parties concerned.

The research study is directed at answering to the hypotheses postulates that total time and learning time are not related directly, as is now assumed and/or recommended.

The research design does not include any changes to the on-going NTDPMA 16-week apprenticeship pre-employment program. However, in an attempt to assess the results of the training received by the student-apprentice during this 16-week period, both objective and subjective evaluations of student capability was made. This information was felt to be of direct import to the definition of learning and demonstration time. This, especially, as it was applicable, was of paramount importance during the conduct of the OJT phase of the first year of apprenticeship.

The major research design feature was to select students in a random and matched manner and to place an equal number into two groups. Group I was subjected to a specifically programmed course of instruction and had learning and demonstration times recorded per machine per task. Group II was allowed to proceed through the regular on-going OJT apprenticeship phase with total time noted as the time was spent on various machine tasks. Group I and Group II apprentices were then compared on the basis of: (1) specific learning-demonstration time on programmed machine-tasks versus the regular recorded time-dimension and learning-demonstration criteria of the on-going program structures; and (2) total amounts of time spent on all machine tasks, programmed or not, by all apprentices from both groups, covering basic and advanced tasks and repetition as they occurred.

Group I

The content and performance criteria for the Group I research students was determined by an industrial survey of NTDPMA member company owners and pre-employment training instructors. This information was then formulated into the curriculum content and process design so that the apprentice would be presented with a sequence which would develop skills and knowledge in logical progression. The curriculum was designed to allow the employer the greatest latitude possible in student rotation thereby providing increased, unconstrained time frames to evaluate and assess the apprentice's progress in the acquisition of knowledge, skill, attitude, and work habits. This research group recorded only learning time for a specific task, not total time. (See Table I for Survey Results).

The Drill, Mill, Lathe and Grinder form the basic machine nucleus of the vast majority of tool and die companies within the NTDPMA. Despite the advancement of technology which has characterized the industrial community over the past several decades, these machines, due primarily to their versatility, are used extensively in the manufacture of new products. Their importance as a foundation in the apprentice learning process is underscored by the fact that the NTDPMA promulgated, Department of Labor approved model for the present four-year apprenticeship in the tool and die industry suggests that better than 4,600 hours of the total 8,000 hours be spent in mastering these machines. In addition, the

TABLE 1

FIRST YEAR CURRICULUM SURVEY

COMPANY INTERVIEW RESULTS

TASKS	PERCENTAGE OF RESPONDENTS PLACING THESE TASKS IN FIRST YEAR
ENGINE LATHE	
Turning	100%
Facing	100%
Chamfer	92%
Drill	100%
Boring	67%
Grooving	58%
Knurling	75%
Right-Hand O.D.	42%*
Right-Hand I.D.	33%*
Undercutting	56%
Reaming	56%
SURFACE GRINDER	
Grind Flat	77%
Parallel	77%
Inside Wheel Shoulder	38%*
Grind Angle	31%*
Cut-Off	46%*
Undercut	38%*

TABLE 1 (Cont.)

TASKS	PERCENTAGE OF RESPONDENTS PLACING THESE TASKS IN FIRST YEAR
CYLINDRICAL GRINDER	
Face Grinding	54%
Traverse Grinding	54%
Plunge Cut Grinding	46%
Shoulder Grinding	38%*
Grinding Centers	38%*
DRILL	
Drilling Thru	92%
Drilling to Depth	77%
Drilling Angular	62%
Counterboring	46%*
Reaming Thru	85%
Reaming to Depth	69%
Hand Reaming	77%
Machine Tapping	69%
Hand Tapping	85%
Countersinking	38%*
Back Spot Facing	38%*
MILLING MACHINE (Vertical)	
Face Milling	92%
End Milling	85%
Slab Milling	77%

TABLE 1 (Cont.)

TASKS	PERCENTAGE OF RESPONDENTS PLACING THESE TASKS IN FIRST YEAR
MILLING MACHINE (Vertical) Continued	
Slotting	54%
Drill and Ream	62%
MILLING MACHINE (Horizontal)	
Face Milling	92%
Slab Milling	77%
Keyway Cutting	54%
Slotting	54%
Saw Blades	46%*
Straddle Milling	38%*

*While several of the tasks indicate that less than 50% of the respondents felt that these tasks belonged in the first year of apprenticeship, there was a general consensus that the tasks should be learned at or near the beginning of the second year.

The industry indicated that the first year apprentice would address these tasks by degree, and therefore the decision was made to include them in the first year curriculum.

suggested standards for the initial year of apprenticeship recommends 1,750 hours for these machines out of the total of 2,000 hours for the first year. As these suggested standards reflect the values and judgments of better than 1,600 member companies, the importance of these four basic machines cannot be disregarded.

In view of the importance of these machines to the tool, die and precision machining trades the research design retained the emphasis placed on these machines. The research study design incorporated the tasks, both basic and advanced as were determined to be applicable. (See Illustration I). These machine-tasks are not, necessarily, delineated and emphasized in order to construct a standard for the first year capability of an apprentice. These specific machine-tasks were compiled and ordered by virtue of an intra-industrial survey and reflect the industry's position on what would be considered acceptable performance by an apprentice at the end of the first year.

The first group of tasks, listed as basic, are those deemed to be essential and interdependent by advancing from the simple to the more complex. The advanced tasks are not (totally) inherently more difficult, per se, but are those which generally are accomplished during or after some sequence of a more basic nature.

The sequencing of an apprentice through the machine-core and accomplishment of basic and/or advanced tasks is shown in Illustration II. The first group of basic tasks contained those of an essential nature. The accomplishment of the basic tasks formed the basis for understanding the principles and operation of that machine as well as providing the skills and knowledge base necessary to advance through the sequence in the manner shown.

The sequence of training to be accomplished on the four basic machines was arrived at after extensive counsel with training directors, instructors and journeymen within the precision machining industry. This consensus felt that the sequence of apprentice training which would most facilitate the progressive acquisition of skill and knowledge, would be the Drill, Mill, Lathe and Grinder.

The drill has characteristics which were considered in its selection as the initial training machine. The workpiece is stationary and the cutting tool rotates when being fed into the material. The speed of rotation and the feed of the tool into the workpiece, while having gross guidelines, are not normally of a critical nature. In addition, "stops" on the spindle preclude the possibility of drilling to an excessive depth. The cautious or unsure apprentice can "underdrill" or cut a hole of a diameter less than called for and, by increasing drill size, progressively re-drill to achieve the required dimension. A basic knowledge of materials and cutting tools is required, as well as "speeds and feeds". Also, the "setting up", or securing of stock on a drill table is normally not a complicated process, and usually embodies the use of common mounting devices, such as parallel blocks

ILLUSTRATION I

FIRST YEAR CURRICULUM TASK GROUPINGS

DRILL

Basic Tasks

1. Drill Thru
2. Drill to Depth
3. Machine Ream Holes (thru)
4. Counterbore Holes
5. Countersink
6. Hand Tap Holes
7. Machine Tap Holes

Advanced Tasks

1. Hand Ream Holes
2. Machine Ream to Depth
3. Drill Angular Holes
4. Spot Facing

MILL

Basic Tasks

Vertical Miller

1. Face Milling
2. End Milling
3. Drill
4. Ream
5. Slotting

Advanced Tasks

Vertical Miller

1. Slab Milling

Horizontal Mill

1. Face Milling
2. Slab Milling
3. Keyway Cutting
4. Slotting
5. Saw Blades
6. Straddle Milling

LATHE

Basic Tasks

1. Straight Turning
2. Shoulder Turning
3. Facing
4. Drilling
5. Chamfering

Advanced Tasks

1. Reaming
2. Knurling
3. Boring
4. Grooving
5. Undercutting
6. Right Hand O.D. Threading
7. Right Hand I.D. Threading

ILLUSTRATION I (Cont.)

GRINDER

Basic Tasks

Surface Grinder

1. Grind Flat
2. Grind Parallel

Advanced Tasks

Surface Grinder

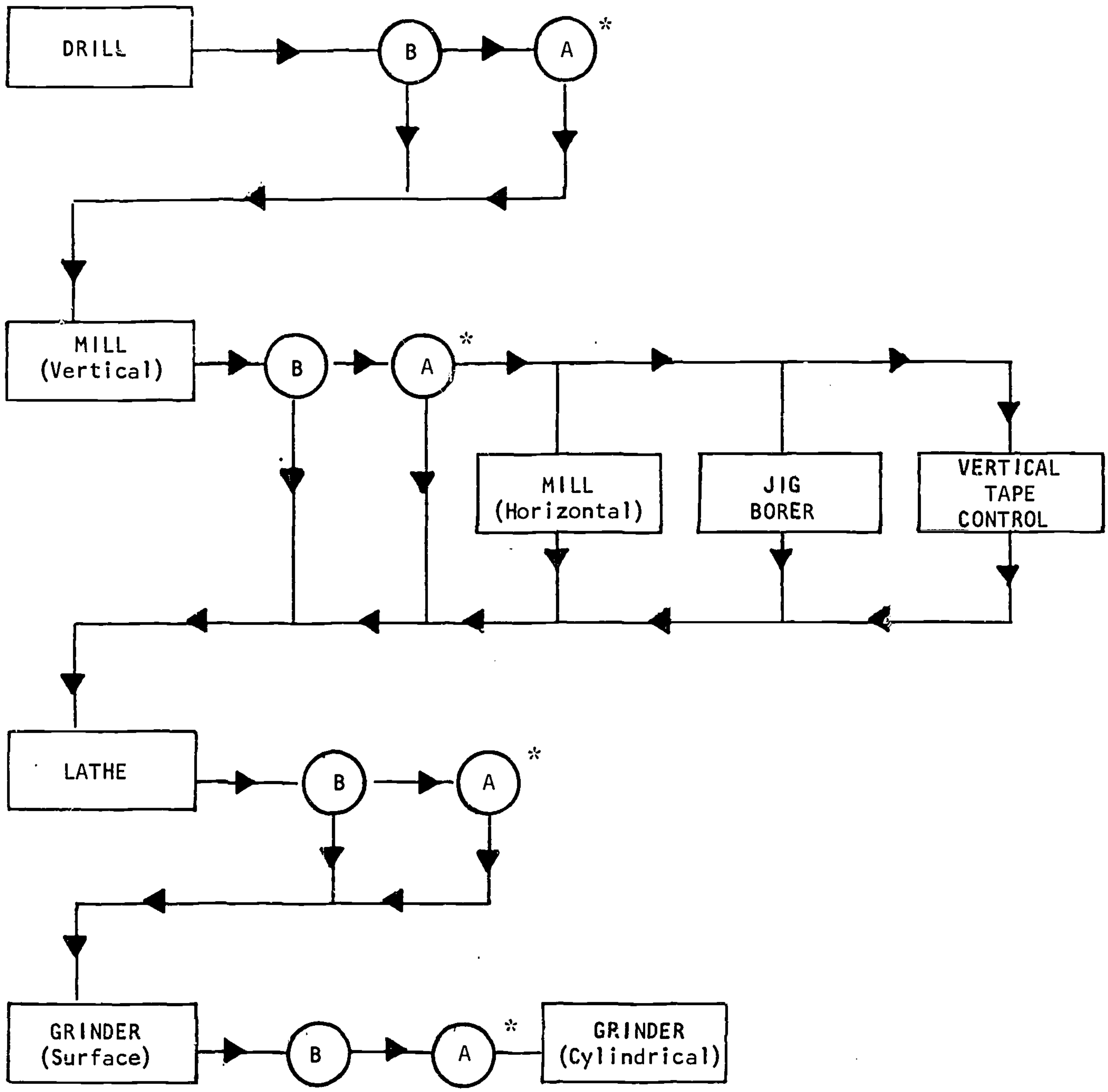
1. Cut-Off
2. Grind Angular
3. Undercut
4. Side Wheel Shoulder

Cylindrical Grinder

1. Face Grinding
2. Traverse Grinding
3. Plunge Cut Grinding
4. Shoulder Grinding
5. Grinding Between Centers

ILLUSTRATION II

FIRST YEAR APPRENTICESHIP TRAINING SEQUENCE



* Any "advanced" tasks by-passed in progessing from machine to machine may be acquired at any point at which they are available during the training process.

or vise. The use of these processes require rudimentary knowledge in this area, but not the highly refined skills required of other machines. Basic measuring devices are employed by the apprentice in the set-up and inspection of the product, such as verniers, gages, plugs and micrometers.

Once the apprentice has demonstrated his attitudes, work habits, and basic skill on the drill, the next machine on which he should be trained is the vertical mill. Industrial surveys tend to illustrate an increasing emphasis on the use of this machine to perform the generalized work which characterizes the precision machining, tool and die industry.

The milling machine is capable of a wide variety of work, both simple and complex. The degree of machining difficulty can be matched to the apprentice's skill and increased according to the progress of the apprentice. The operation of this machine employs principles which will facilitate the apprentice's transition to such machines as the jig bore, horizontal mill, and vertical tape control should the situation require. The transition from the drill to the mill is dictated by the operational characteristics which the two machines have in common. The apprentice will easily note that the mill and drill both employ vertical spindles which function perpendicularly to the table. In addition, the cutting tool is mounted in the same manner for both machines and fed into the workpiece in the same manner. Both the drill and mill employ similar RPM selection, each having approximately eight speeds, each within a few hundred RPM of each other. On both machines the workpiece is stationary while the tool rotates to remove metal. In many instances the same simple mounting tools are used, such as the vise and parallel blocks. Basic inspection tools are employed for this machine, reinforcing the knowledge gained on the drill.

Thus, a functional knowledge of the mill provides, as soon as possible in the training process, the skills and knowledge which will maximize the apprentice's capability while at the same time evidencing a wide variety of commonalities with the drill and other related machines, facilitating the transition between machines.

The next machine in the sequence of apprenticeship training is the lathe. While the apprentice has become familiar with speeds and feeds in the operation of the drill and mill, this machine is characterized by the criticality of speeds and feeds. While the general principles of metal cutting still apply, the lathe is primarily concerned with the removal of metal from a circular work base and employs a stationary cutting tool while the workpiece rotates. This is in contrast to the preceding two machines. As the lathe is capable of both rough and precise work, the apprentice can be utilized at his particular level of ability. In addition, sharpening of cutting tools and the use of mounting devices are similar to those employed on the drill and mill in many instances, depending upon the physical task being performed. Finally, the use of measuring devices, such as taper gages, depth gages, micrometers, vernier scales and go-no-go plugs are common for this machine as well as for the drill and mill.

The last of the four basic machines in this sequence on which the apprentice should be trained is the grinder. In order to understand why this machine is last we must look in retrospect at the sequence of instruction which the apprentice has received prior to this machine. Initially, he was indoctrinated to the new working environment by utilizing his talents on the drill, a simple machine which did not require fine tolerances. From this he progressed to the mill, a machine similar in many aspects to the drill, but providing more of a challenge while at the same time maximizing his benefit to the employer. From there he moved on to the lathe, a machine related in function to the mill but embodying new concepts in machining. Throughout this learning process the apprentice has been constantly challenged by new machines and processes, increasing his proficiency and knowledge and providing himself with the information and skills required to grasp a comparatively unique machine and machining process.

The grinder embodies a new concept in metal removal. For the first time the apprentice is confronted with non-metallic metal removal. The drill, mill, and lathe all utilize a metal tool to removal metal from a piece of stock, while the grinder employes an abrasive wheel, non-metallic, to accomplish the same purpose. While the basic "set-ups" on this machine involve little expertise in this area, highly sophisticated tools and devices can also be employed for special grinding. The criticality of surface finish is of highest importance in the operation, and requires a degree of ability not normally called for in the preceding three machines. In addition, this machine introduces the new concept of the workpiece moving into the cutting tool, while the basic tasks on the mill, drill, and lathe employ the opposite principle. Because the speed of the cutting tool is constant, the feeding of the workpiece into the cutting tool becomes critical.

As grinding is generally one of the last operations in the manufacture of a product, it is obviously the point, should an error occur, at which the employer will realize the greatest loss. In addition, any work on the grinder normally requires a high degree of manual dexterity. Obviously, the apprentice not only needs a great degree of skill and knowledge but also confidence and experience to operate this machine in a productive manner.

D. Limitations and Constraints

The following limitations and constraints affected the conduct of the research study program concerned with pre-apprenticeship training and subsequent OJT activities:

(1) The variety of starting and finishing dates of the pre-apprenticeship training programs, from which Group I and Group II students were selected, were not capable of being time-phased matched to the starting date and subsequent 12-month research-data acquisition segment of the research study;

(2) The differences in the total number of students reporting and being assessed during the conduct of the last six months of the research study 12-month reporting time period causes a slight loss in the confidence level assignment when the data is extrapolated and used for inferential purposes. This loss of data was primarily caused by:

(a) Pre-apprenticeship training and research programs starting dates mis-match with subsequent student unavailability for an entire 12-month reporting period; and

(b) A student attrition rate of approximately 40%; causing the loss of later programmed machine-task data.

(3) Individual apprentice sequencing and the accomplishment of all machine/tasks could not be maintained for all apprentices. This was primarily due to the constraints inherent in the economic environment in which the study was conducted, such as production schedules, and non-availability of work.

(4) The skills and knowledges of the apprentices were not assessed with respect to subsequent OJT performance criteria. The apprentices finished the 16-week pre-apprenticeship program without this information being established. Therefore, this data was not available for comparative use as it affected learning time in later OJT activities.

(5) The data obtained from the two groups of apprentices presented herein is subject to the following constraints:

(a) Based on prior pre-employment programs of a similar nature, an attrition rate of approximately 35% was anticipated. The attrition rate for these research students during the research program approximated 45%.

(b) The times recorded by both groups reflects in many instances the total process of machining for that particular task, from stock selection to final inspection.

(c) The lack of availability of tasks for the Group I apprentices to accomplish subsequent to the basic tasks for each machine reduced the data available after the initial six months of on-the-job training.

(d) When discussing the Group II apprentices who recorded total time for a given task and the average hours per task, the hours were not necessarily acquired at one time.

CHAPTER IV

DATA ANALYSES

A. Introduction

The present model Apprenticeship Machine and Time Standards, promulgated by NTDPMA, were approved by the Bureau of Apprenticeship and Training as a model for apprenticeship training in the tool, die and precision machining trades. (See Table 2). They were developed and approved only as guidelines upon which an individual company could base their own standards. As such, they are subject to some variance according to the desires of that company. It should be remembered that, while these model Standards are recommendations only, they reflect the idealized consensus of over 1,600 member companies across the country.

TABLE 2

NTDPMA MACHINE-TIME APPRENTICESHIP STANDARDS (FIRST YEAR)

	Recommended Hours	Percentage of Total Time
Tool Crib	125	6%
Drill Press	350	17%
Milling Machine	500	25%
Lathe	500	25%
Grinder	425	21%
Miscellaneous Machines	100	5%
	2,000	99%

In order to provide a normal apprenticeship training program time-machine baseline, the Houston, Texas apprenticeship traing program was monitored during its first year of operation. This time-machine-task information is typical of the nature of the present NTDPMA training program conducted at the various locations.

The specific information relating and comparing actual program time-machine-task accomplishment and the recommended time-machine "standards" in Table 2 is included in Appendix K.

The average time logged by these Houston apprentices was 2,291 hours. Two hundred and ninety-one hours were in excess of the minimum time required to satisfy the model standards. Despite the hours in excess of standards that were worked by first-year apprentices, 20 of the 30 apprentices did not work the recommended 500 hours on the mill, and 19 did not meet the 500-hour recommendation for the lathe. Twenty-one of the 30 apprentices did not meet the recommended national standard of 425 hours on the grinder and four apprentices did not log any hours at all on this basic machine. Nineteen of the 30 apprentices did not meet the 350-hour requirement for the drill. While each apprentice worked an average of 291 hours in excess of the minimum first-year requirement, not a single student achieved the minimum standard for all four basic machines. Of the 30 students who reported hours for each of the four basic machines, only 41 entries met the minimum standard.

This typical example of the time-machine-apprenticeship profile as it occurs in actual practice, presents a large fluctuation of time when compared with the present model standards. The variations of time and task inherent in the typical apprenticeship program do not give cause for inferring that any is "wrong" per se. What is important is that the implied program structure is not being adhered to and that learning time and capability parameters are not being considered in the proper manner.

The on-job training comparative-research study curriculum was developed in order to provide sequencing of task processes, as well as specified definition and performance criteria; information from which learning time could be derived. In this manner, machine-task learning time could be discerned and related to the total time recommended and/or being scheduled.

B. Group I Program Analysis

In accordance with the prescribed curriculum, the apprentices in Group I recorded a comparative majority of tasks learned on the drill, then, following in order, the mill, lathe and grinder.

The four basic machines comprising the prescribed first year OJT curriculum reflected the following data for the Group I apprentices.

On the drill, 37 apprentices indicated having satisfied the learning requirement for an average of six tasks. The average learning time per task was 15.5 hours. This ranged from a low average of three hours (machine ream to depth) to a maximum average of 52 hours (counterboring holes). The majority of apprentices reported learning time on the basic tasks. Of the total tasks* reported by Group I, 85% were recorded on the seven basic tasks recommended for the drill. Drilling through showed the most students recording time, followed in order by drilling to depth, countersinking, machine tapping holes, machine reaming holes, hand tapping holes and counterboring holes. (See Table 3, Figure 1).

On the mill, 33 apprentices in Group I indicated having learned an average of six tasks each. The average learning time per task was

*This figure is arrived at by totaling the number of apprentices recording time for each task.

nine hours each. The average learning times for tasks on this machine ranged from a low of two hours (straddle milling), to a high of 18 hours (face milling). Of the total tasks reported by this group, 66% were on the five basic tasks. (See Table 3, Figure 2).

The third machine, the lathe, reflected learning time from 34 apprentices in Group I. These apprentices recorded learning an average of six tasks each, with an average learning time of 7.5 hours per task. The low average learning time for a task was two hours (right hand I.D. threading), while the high average learning time per task was 11 hours (right hand O.D. threading). The basic tasks (straight turning, shoulder turning, facing, drilling and chamfering) were learned by this group of apprentices, 75% were on the five basic tasks recommended for the lathe. Drilling showed the most students indicating learning, followed by straight turning, shoulder turning, facing and chamfering. (See Table 3, Figure 3).

The least number of students, 25, recorded learning time on the grinder. These apprentices indicated learning an average of four tasks each, with an average learning time of seven hours for each task. The lowest average learning time for a task was two hours per task (undercut, side wheel shoulder, plunge cut), while the maximum average learning time for a task was nine hours (grind flat, grind parallel). Two of the basic tasks, grinding flat and grinding parallel, were learned by the majority of apprentices. Of the total tasks reported as learned by the apprentices, 50% were on these two basic tasks. (See Table 3, Figure 4).

C. Group II Program Analysis

The Group II apprentices recorded exposure time (total time) to principally the same tasks as Group I. The four basic machines indicated the following data for Group II apprentices.

For the drill, 43 students in Group II indicated an average exposure time of 24 hours per task. The average number of tasks to which each apprentice was exposed was seven. The minimum average time for a given task, three hours, was recorded for hand reaming holes, while the maximum average time was 58 hours, for drilling through. (See Table 3, Figure 1).

The majority of apprentices in this group recorded exposure to the basic tasks. Of the total tasks reported by this group, 79% were recorded for the basic tasks. The tasks of drilling through, drilling to depth, and countersinking showed the most apprentice exposure (43 students, 37 students and 37 students respectively), closely followed in sequence by machine reaming holes, counterboring, machine tapping, and hand tapping.

On the milling machine, 43 students indicated exposure to the various tasks, with an average exposure time of 44 hours per task. The average number of tasks to which an apprentice was exposed was five. This exposure time ranged from a low of 16 hours (reaming) to a high average time of 90 hours (saw blades). (See Table 3, Figure 2).

The two tasks which were recorded by the most students were face milling (40) and end milling (43), followed by drilling (29), slotting (29), and reaming (22). Of the total tasks reported by Group II, 71% were on these basic tasks.

The third machine, the lathe, showed 37 apprentices indicating exposure time, with an average of 38 hours per task. On average, each apprentice was exposed to six tasks. The range of average time per task went from a low of six hours (knurling) to a high of 81 hours (straight turning). (See Table 3, Figure 3).

The tasks on which the most apprentices indicated time were straight turning (37), facing (36), drilling (30), chamfering (23), and shoulder turning (21). Of the total tasks reported for Group II on the lathe, 62% were recorded on these five basic tasks.

The grinder showed the least number of apprentices recording time (27), and the lowest average for all task exposure time of 33 hours. In addition, each apprentice was exposed to an average of four tasks. The range of average time per task extended from a low of two hours (traverse grinding) to a high of 52 hours (grind flat). The two tasks which showed the highest number of apprentices being exposed were grinding flat (27) and grinding parallel (18). Of the total tasks reported for this machine, 45% were on the basic tasks. (See Table 3, Figure 4).

D. Composite

When the four basic machines recorded were considered as a group, the average learning time for Group I was 10.5 hours per task, while the average time per task recorded for Group II was 34 hours. The average number of tasks learned by each apprentice in Group I was 19, and the average number of tasks to which an apprentice was exposed in Group II was 20.

Both Groups I and II showed major emphasis on the basic tasks for each of the machines. In Group I, of 720 total tasks having been reported as learned, 522 were recorded against the basic tasks, while in Group II, out of 883 total tasks reported, 606 were on the basic tasks.

TABLE 3, FIGURE 1

TASK	GROUP I			GROUP II		
	Hours	# of Students	Average	Hours	# of Students	Average
BASIC						
Drill Thru	786	37	21	2,536	43	58
Drill to Depth	371	30	12	1,210	37	32
Machine Ream Holes	181	24	7	461	34	13
Counterbore Holes	1,212	23	52	530	34	15
Countersink	273	28	9	506	37	13
Hand Tap Holes	159	24	6	584	32	18
Machine Tap Holes	350	28	12	771	34	22
ADVANCED						
Hand Ream Holes	56	10	5	35	10	3
Machine Ream Depth	35	9	3	158	18	8
Drill Angular Holes	50	6	8	83	11	7
Spotfacing	59	6	9	88	12	7
Unspecified Task	28	4	7	364	5	72
Unspecified Task				46	4	11
Unspecified Task				47	2	23
	3,560	229	15	7,426	315	23

TABLE 3, FIGURE 2

TASK	GROUP I			GROUP II		
	Hours	# of Students	Average	Hours	# of Students	Average
BASIC						
Vertical						
Face Milling	250	26	9	1,845	40	46
End Milling	383	33	11	2,639	43	61
Drill	205	29	7	1,570	29	54
Ream	128	18	7	367	22	16
Slotting	183	20	9	695	29	23
ADVANCED						
Vertical						
Slab Milling	104	12	8	348	14	24
Unspecified Task	70	8	8	329	2	164
Horizontal						
Face Milling	126	7	18	364	10	36
Slab Milling	55	9	6	443	10	44
Keyway Cutting	109	12	9	428	10	42
Slotting	96	8	12	230	7	32
Saw Blades	23	4	5	452	5	90
Straddle Milling	8	3	2	50	3	16
Unspecified Task	12	3	4	384	5	76
	1,755	193	9	10,162	230	44

TABLE 3, FIGURE 3

TASK	GROUP I			GROUP II		
	Hours	# of Students	Average	Hours	# of Students	Average
BASIC						
Straight Turning	258	29	8	3,018	37	81
Shoulder Turning	165	22	7	646	21	30
Facing	214	28	7	1,543	36	42
Drilling	215	34	6	1,083	30	36
Chamfering	138	20	6	456	23	19
ADVANCED						
Reaming	83	12	6	400	11	36
Knurling	25	7	3	69	11	6
Boring	126	20	6	905	20	45
Grooving	62	9	6	295	11	26
Undercutting	45	5	9	193	9	21
R/H O.D. Threading	89	8	11	312	12	26
R/H I.D. Threading	13	5	2	172	8	21
Unspecified Task	63	6	10	87	6	14
Unspecified Task	33	3	11	6	1	6
	1,564	209	7	9,202	237	38

TABLE 3, FIGURE 4

TASK	GROUP I			GROUP II		
	Hours	# of Students	Average	Hours	# of Students	Average
BASIC						
Grind Flat	247	25	9	1,430	27	52
Grind Parallel	192	20	9	829	18	46
ADVANCED						
Cut-Off	28	10	2	60	11	5
Grind Angular	59	8	7	350	13	26
Undercut	12	5	2	147	7	21
Side Wheel Shoulder	13	6	2	80	8	10
Cylindrical Grinder						
Face Grinding	6	2	3	194	5	38
Traverse Grinding	10	2	5	4	2	2
Plunge Cut	8	3	2	22	3	7
Shoulder Grinding				76	2	38
Grind Between Centers	23	4	5	117	3	39
Unspecified Task	3	1	3			
Unspecified Task	25	1	25	29	1	29
	632	89	7	3,340	101	33

CHAPTER V

FINDINGS AND CONCLUSIONS

A. Results of the Study

The general research design purpose was to develop and implement an accelerated on-the-job apprenticeship training program which could comply with the first year time-machine standards of the present yearly based time-machine standards recommended by the NTDPMA and BAT.

The design encompassed a specific time-phased program in which apprentices of Group I participated. The results of this experiment were compared to the results obtained from Group II apprentices who participated in the typical program as now conducted within the trade. These results were used to test the validity of the two main hypotheses:

(1) The recommended total time per machine -- now forming the time constraint for the design and conduct of the first year of a typical NTDPMA apprenticeship training program -- is not a true indicator of learning time.

(2) The learning time necessary to acquire and demonstrate competency and capability requirements for selected tasks per machine -- determined by the industry to be expected of (an average) first year apprentice -- is shorter than the total time recommended.

The results of the study are as follows:

1. The Group I average learning time* for the 46 specific machine tasks was 10.5 hours per task. (These tasks are delineated and grouped within the four basic machines nucleus, see Table 1, Figures 1, 2, 3 and 4).

2. The Group II average exposure time* for the 46 specific machine tasks was computed to be 34 hours per task. (See Table 1, Figures 1, 2, 3 and 4).

3. The expected total time necessary to learn* 46 specific tasks by Group I apprentices is calculated to be:

   10.5 hours per task x 46 tasks = 483 hours

4. The expected total exposure* time necessary to encompass 46 specific tasks by Group II apprentices is calculated to be:

   34 hours per task x 46 tasks = 1,564 hours

*Note - refer to Glossary for definition of learning time and exposure time.

5. The work-concentration percentages on the 46 specific tasks encountered by both Group I (programmed) apprentices and Group II (un-programmed) apprentices were:

Group I:	522 machine tasks learned	(basic)	= 73%
	720 learned tasks	(total)	
Group II:	606 tasks exposure	(basic)	= 69%
	883 tasks exposure	(total)	

6. The average number of specific tasks completed by an apprentice were:

   Group I (programmed) = 19 specific tasks learned.

   Group II (un-programmed) = exposure to 20 specific tasks.

7. The comparison of accomplishment of the 46 specific tasks by each apprentice Group, I and II, reveals that:

   a. When learning time is assessed specifically, the time reported is shorter than that time formerly reported when exposure time was the baseline for "successfully" completing the first year of the typical apprenticeship program.

   b. Exposure time is not a true indictor of learning time, when agreed upon standards for first year apprentice capability are designated and defined.

   c. Basically, the same machine tasks are performed by most apprentices during the first year of the present typical apprenticeship training program.

   d. Exposure time and learning time cannot be equated in meaning nor in the learning time dimension.

   e. The result study designed apprenticeship program processes and concent are of significant importance for further use in determining time-based capability and competency "standards" for apprentices, during the first phase of a total apprenticeship program which culminates in the title Journeyman.

   f. The first year of on-going typical apprenticeship training programs does not, necessarily, follow the NTDPMA/BAT time-machine recommended standards.

The hypotheses that: (1) the present hours per machine for the conduct of the first year of apprenticeship are not valid indicators of learning time; and, (2) the length of time required to acquire and demonstrate the skills and knowledges determined by the industry to be necessary for the first year of apprenticeship is less than the total times recommended; have been substantiated.

The research-study learning time reported for the 46 specific machine tasks, accepted and approved by the industry as being indicative of capability and competency requirements for a first year apprentice, show, approximately, a ratio of

$$\frac{\text{500 hours (average learning time)}}{\text{2,000 hours recommended time}} = 25\%$$

This indicates that the specified machine tasks can be learned (on the average) in 25% of the recommended time. However, the range of learning time will extend the upper limit of learning hours giving a learning time range of up to 35%, approximately. This is still a considerable shorter period than that now recommended. Also, these figures assume that learning, as specified and discerned, in the research study is equally rigorous in the exposure time dimension of presently conducted programs.

Therefore, the learning time being less than the recommended times of the present NTDPMA/BAT standards, it follows that the presently recommended hours are not valid indicators of learning time.

The learning hours, 10.5 average hours per task versus the exposure hours, 34.0 average hours per task demonstrate that the time necessary to learn the required machine tasks are less than those recommended.

B. Discussion of the Results

The results of this study indicate that the present 2,000-hour standard for the first year of apprenticeship programs can be reduced significantly. The learning time parameter indicates that this time-shortened program could be 25 percent of the present time period. A mediated figure would be estimated at approximately 35 percent of the total time when idiosyncratic learning factors are taking into consideration.

These results have, also, supported a major finding of an apprenticeship training program research study conducted by Rigby and Eiffert (1971). Their findings indicated that total time was not as important as how the time was spent. The programmatic aspects of the conducted research-study support findings of Barroci (1971), Drew (1969), and Horrowitz and Herrnstadt (1969) concerning learning time related to machine-task identification, progressive task-skill acquisition, and apprentices gaining a feeling of competence in task performance.

The use of a programmed course of instruction has been proven beneficial by degree. The program structure aided in allowing individual advancement based on progressive task mastery on the basic machines as requisite tasks were demonstrated successfully to the terms imposed by the measure "learning time". The programmatic aspects also helped to recognize learning time as a better measure of learning rather than to continue accepting the looser term, exposure time as the measure by those persons doing the assessing.

In actual practice, the course of instruction was not rigorously adhered to due to the work environment within which the apprentice performed. However, the benefits of even the semi-program can be discerned. It is felt that non-adherence to the structure worked against time compression by virtue of interruption and limiting reinforcement of skills and knowledges which were building the substantive base progressively.

A factor which is of import to the entire research study, but which could not be included nor proven, was an assessment of learning which took place in the 16-week pre-employment training program. The survey of pre-employment instructors indicates that they believe the apprentice capable of performing approximately 50% of the machine-tasks which the apprentice be held responsible for during the first year, at the time of leaving the pre-employment training phase. This research-study was undertaken at a time when the pre-apprenticeship training programs were in various stages of competition and could not be evaluated for inclusion in this study.

C. Conclusions and Implications

The results of the research study indicate the following:

(1) Present apprenticeship time-machine standards do not provide adequate measure of learning time needed to meet the requirements of the average first year apprentice.

(2) The learning time necessary to comply with the first year requirements of an apprenticeship program is less than the time-machine recommended standards.

(3) It would appear that the present conduct of typical apprenticeship training programs would benefit from certain modifications which would make them more compatable with the desires of industry and the needs of the apprentices.

(4) Apprentices trained in a programmatic manner achieve the desired first year level of knowledge and skills in a shorter time period than do apprentices in typical on-going training programs.

(5) The use of exposure time as an indicator of the learning time dimension in apprenticeship training programs is invalid.

(6) An effective and efficient OJT apprenticeship program phase is not now being conducted in the present trade environment.

The implications for changes in apprenticeship training program theory, design and implementation are manifold. The theory underlying the establishment of the present time-machine first year standards of apprenticeship training programs is suspect and seems to be excessive by a large degree.

Presently designed apprenticeship training programs are relatively insensitive to apprentice needs as well as to the efficiency and effectiveness criteria necessary to the trade. When these programs are implemented, they lose their inherent effectiveness. This is primarily due to the constraints and limitations of the trade environment. These attenuate the total program goals in favor of immediate trade needs in the prevailing dimension encountered at a point in time.

The present typical apprenticeship programs posture, in the time, money, skills and capability dimensions, takes away from the hoped-for professional image of the apprentices/journeymen and makes recruitment and retention a difficult problem. This becomes evident when the drop-out rate and ultimate disposition is addressed. Most of the drop-outs of these programs find higher paying jobs in related trades rather soon after dropping out. At the present time it would appear, at a 40 percent apprentice drop-out rate, that the trade is training machinists for the general machining industry rather than for the tool, die and precision machining industrial segment.

A major implication of this study is its support for the recommendations, changes and further research of other related research. All the studies seem to find a variance in the competencies, and capabilities inherent in the term journeyman. This greatly beclouds the industry journeyman image while at the same time raising serious doubts as to the ability of these training programs to complement the manpower policy dimensions of intra-trade vertical and lateral mobility and continuing career ladder opportunities for apprentices and journeymen.

It appears that if a new program theory, design and implementation concerned with developing new parameters were to be developed, the tool, die and precision machinist apprenticeship training programs would more promptly serve the needs of the various parties and agencies concerned.

This dimension must be considered very seriously in the near future as the ineffectiveness of the present program structure is causing serious skilled manpower replacement problems now. This has been the case over a long period of time, as it has taken Federal Government money to help stabilize it at the present level, which is still not at the maximum level hoped for.

D. Suggestions for Further Research

The major suggestion for further research lies in assessing the total tool, die and precision machinist apprenticeship program and designing, developing, implementing and evaluating a new and/or up-dated training program. This research effort is completely supported by the results of this study and other related research undertaken in the same general problem area.

The first phase of such an undertaking would be to assess and value the present pre-apprenticeship program and its relationship to the following time period and ultimate journeyman criteria. The second phase would assess and value the present OJT segment which leads to the title Journeyman.

The third phase would review and analyze the information in order to properly change the program structure to meet the needs of the parties concerned.

The fourth phase would implement the program and evaluate the results.

Unless this type of action is taken, the best that can be hoped for is a slow "reactive" piecemeal change program which will minimally serve selected interests. It is hoped that these suggestions will be taken seriously in the near future.

A P P E N D I X

APPENDIX A

TITLE	OBTAINABLE FROM:
First Year Technical Proficiency Evaluation Test	NTDPMA 9300 Livingston Road Washington, D.C. 20022
Test of Mechanical Comprehension Form AA	The Psychological Corp. 304 East 45th Street New York, New York 10017
Apprenticeship Standards for Die Maker, Mold Maker, Precision Machinist and Tool & Die Designer	NTDPMA 9300 Livingston Road Washington, D.C. 20022

APPENDIX B

Name ______________________________

Month ____________________ 19 ___

Day	Hours Worked on Each Type of Operation																
Br'ght Forward	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Total	Foreman's Initials
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	
13																	
14																	
15																	
16																	
17																	
18																	
19																	
20																	
21																	
22																	
23																	
24																	
25																	
26																	
27																	
28																	
29																	
30																	
31																	
TOTAL																	

CODE: E - EXCELLENT G - GOOD F - FAIR P - POOR

Shop Work Grade This Month ____________________

Foreman ____________________

NTDPMA Instructor ____________________

APPENDIX C

NTDPMA PRE-APPRENTICESHIP STUDENT INFORMATION SHEET

BLOCK 1	BLOCK 2
NAME: ____________ AGE: ____	DATE OF BIRTH: ____________
ADDRESS: ____________	HEIGHT: ________ WEIGHT: ________
____________	U.S. CITIZEN: ____________
S.S.#: ________ PHONE: ________	MILITARY CLASSIFICATION: ________
MARITAL STATUS: ____________	MILITARY SERVICE: ____________
NO. OF DEPENDANTS: ____________	LOTTERY NO.: ____________
TRANSPORTATION: ____________	
PHYSICAL DISABILITIES: ____________	

BLOCK 3

IN CASE OF EMERGENCY - NOTIFY (NAME, ADDRESS, TELEPHONE): ____________

HOW WERE YOU INFORMED OF THIS PROGRAM? ____________

BLOCK 4

LEVEL OF EDUCATION: ____________ WHEN GRADUATED: ____________

DID YOU HAVE (CIRCLE ANSWER): CHEMISTRY: YES NO PASS FAIL

MATHEMATICS: YES NO PASS FAIL OTHER: ____________

ALGEBRA: YES NO PASS FAIL OTHER RELATED TRAINING: YES NO

GEOMETRY: YES NO PASS FAIL PASS FAIL

PHYSICS: YES NO PASS FAIL WHERE: ____________

BLOCK 5

RELATED WORK EXPERIENCE (WHAT-WHERE-WHEN):

Do not write below this line

GATB 1 2 3 4

DISADVANTAGED YES NO

APPENDIX D

SHORT FORM -- STUDENT PRACTICAL APPLICATION RATING SYSTEM

Rate, by number, each student in the following two areas for each of the six categories listed below:

Column A -- DEGREE OF COMPETENCE

1. Unsatisfactory
2. Below Average
3. Average
4. Above Average
5. Outstanding Performance

Column B -- LEARNING SPEED

1. Slow Learner
3. Average Learner
5. Fast Learner

NAME	ENGINE LATHE		SURFACE GRINDER		CYLIND'L GRINDER		DRILL		MILLING MACHINE		INSPECTION	
	A	B	A	B	A	B	A	B	A	B	A	B

NTDPMA

EMPLOYEE PERFORMANCE EVALUATION FORM

Name ______________ Rating Period ______________ Job Title ______________

Evaluated by ______________ Date ______________ Approved by ______________ Date ______________

PLEASE KEEP IN MIND THAT PERFORMANCE EVALUATION IS VERY IMPORTANT TO THE COMPANY AND TO THE EMPLOYEE. THE EVALUATOR SHOULD CAREFULLY READ THE SPECIFICATIONS FOR EACH FACTOR, SELECT THE ONE THAT DESCRIBES THE EMPLOYEE'S PERFORMANCE AND PLACE AN X IN THE SQUARE OF THE APPROPRIATE STATEMENT.

						SCORE
1. ACCURACY	☐ Makes too many errors	☐ Always precise & within required tolerances	☐ Usually accurate but makes some errors	☐ Mostly accurate to required tolerances	☐ Makes frequent errors	1. ____
2. QUANTITY	☐ Production exceeds requirements	☐ Barely meets minimum requirements	☐ Maximum possible production	☐ Produces less than minimum requirements	☐ Satisfactory production	2. ____
3. ADAPTABILITY	☐ Average learning ability and has little difficulty to meet new conditions	☐ Below average learning ability	☐ Very slow to learn and adjust to new conditions	☐ Learns fairly quickly and adapts to changed conditions fairly readily	☐ Learns very quickly and adapts to changed conditions readily	3. ____
4. JOB KNOWLEDGE	☐ Moderately knowledgeable in most requirements of his job	☐ Has fair knowledge of all phases of the job	☐ Poorly informed in his job requirements	☐ Lacks some knowledge to do an adequate job	☐ Highly knowledgeable in all phases and requirements of the job	4. ____
5. DEPENDABILITY	☐ Strives to produce maximum production with minimum supervision	☐ Requires moderate follow-up to produce work in reasonable time	☐ Requires some supervision to produce work in reasonable time	☐ Requires little supervision to produce work on schedule	☐ Requires frequent follow-up to meet routine duties	5. ____
6. ATTITUDE	☐ Has an "I do not care what happens" attitude	☐ Puts more effort into job than average employee	☐ Ambitious, imaginative and willing to improve methods. Well liked.	☐ Puts forth only minimum effort to get by	☐ Average cooperation with people, sometimes contributes ideas voluntarily	6. ____
7. ATTENDANCE	☐ Usually on time and seldom absent	☐ Always on time and never absent without advance notice	☐ Seldom late and seldom absent	☐ Usually late and frequently absent	☐ Often late and occasionally absent	7. ____
						TOTAL ____

NTDPMA F-4032

APPENDIX F

CLASS TEST REPORT

Program Number ______________________ Location ______________________

Begin ______________________ End ______________________

Student Name	Mathematics		Blueprint Reading		Check if dropped program
	No. of Grades	Average	No. of Grades	Average	

											DO NOT WRITE IN THESE SPACES			PROCESSES								ACCESSORIES											MATERIALS						
	Check if completed task once to the required performance level	Check if completed task second time to required performance level	Craftsmanship	Safety	Attitudes	Efficient Use of time and Materials	Hours	Apprentice's initials	Evaluator's initials	Date	Apprentice's initials	Evaluator's initials	Date	Select Correct Speeds and Feeds	Select Proper Cutting Tool	Grind Cutting Tool to Produce Efficient Cutting Edge	Set up Lathe for Operation	Secure Stock in Lathe	Inspect Part for Conformance with Blueprint requirements	Other: (list)		3-Jaw Chuck	4-Jaw Chuck	Between Centers	Collet	Faceplate	Arbor	Other: (list)					Cast Iron	Steel	Bronze	Aluminum	Other: (list)		
TASKS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
A. Straight turning Tolerance: ± .003																																							
B. Shoulder turning Tolerance: ± .010																																							
C. Facing Tolerance: ± .003																																							
D. Drilling Tolerance: ± .005																																							
E. Reaming Tolerance: ± .001																																							
F. Chamfering Tolerance: ± .005																																							
G. Knurling																																							
H. Boring Tolerance: ± .003																																							
I. Grooving Tolerance: ± .003																																							
J. Undercutting Tolerance: ± .003																																							
K. Right Hand O.D. Threading Tolerance: ± .003																																							
L. Right Hand I.D. Threading Tolerance: ± .003																																							
M.																																							
N.																																							
O.																																							
P.																																							
Q.																																							
R.																																							

TASK ANALYSIS FORM -- LATHE   Reporting Period ____________ to ____________   Name ____________

TASKS				DO NOT WRITE IN THESE SPACES				PROCESSES									ACCESSORIES														MATERIALS								
	Hours	Apprentice's Initials	Instructor's Initials	Date	Apprentice's Initials	Evaluator's Initials	Date	Select Correct Grinding Wheel	Dress Wheel until it runs true	Make Correct Set-ups	Secure Work in Holding Device	Inspect work for conformance with B/P	Other: (list)				Magnetic Chuck	Vise	Angle Plate	V-Blocks	Magnetic Parallels or V-Blocks	Other: (list)									Cast Iron	Steel	Bronze	Aluminum					
SURFACE GRINDER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
A. Grind Flat																																							
B. Grind Parallel																																							
C. Cut-Off																																							
D. Grind Angular																																							
E. Undercut																																							
F. Side Wheel Shoulder																																							
G. CYLINDRICAL GRINDER																																							
H. Face Grinding																																							
I. Traverse Grinding																																							
J. Plunge Cut Grinding																																							
K. Shoulder Grinding																																							
L. Grinding Between Centers																																							
M.																																							
N.																																							
O.																																							
P.																																							
Q.																																							
R.																																							

TASK ANALYSIS FORM -- GRINDER Reporting Period ______________ to ______________ Name ______________

APPENDIX H

APPENDIX I

SPECIFIC TRAINING LOCATION LIST

Location	No. of Programs
East	
Irvington, New Jersey	(2)
Springfield, Massachusetts	(2)
Peabody, Massachusetts	(1)
Lawrence, Massachusetts	(1)
Quincy, Massachusetts	(1)
Rochester, New York	(5)
Syracuse, New York	(1)
Erie, Pennsylvania	(1)
Mid West	
Racine, Wisconsin	(1)
Dayton, Ohio	(1)
Columbus, Ohio	(1)
Cleveland, Ohio	(1)
Toledo, Ohio	(1)
Bridgman, Michigan	(1)
Rockford, Illinois	(1)
Cincinnati, Ohio	(1)
West	
Los Angeles, California	(3)
Pacoima, California	(1)
Torrance, California	(1)
Azusa, California	(1)
Denver, Colorado	(3)
South	
Fort Smith, Arkansas	(1)
Houston, Texas	(2)
Nashville, Tennessee	(1)
San Antonio, Texas	(1)

APPENDIX J

PRE-EMPLOYMENT PROFILE
STUDENT PERFORMANCE TRAINING PROGRAM

	All Students	Experimental Group I	Control Group II
Age	22	21	23
Education Level	11	12	12
1st Year Technical Proficiency Test - Entry Level	86	96	90
1st Year Technical Proficiency Test - Completion	172	174	175
1st Year Technical Proficiency Test - Difference Between Entry and Completion	54	59	59
Mechanical Comprehension Test - Entry Level	37	39	40
Mechanical Comprehension Test - Completion	44	46	46
Mechanical Comprehension Test - Difference Between Entry and Completion	5	6	6
Employee Performance	74	79	76
SPARS	17/18	18/19	18/18

STUDENT	MILLING Hrs	MILLING %	LATHE Hrs	LATHE %	GRINDER Hrs	GRINDER %	SHAPER Hrs	SHAPER %	ASSEMBLY Hrs	ASSEMBLY %	INSPECTION Hrs	INSPECTION %	MAINTENANCE Hrs	MAINTENANCE %	MISC. Hrs	MISC. %	DRILL Hrs	DRILL %	WELDING Hrs	WELDING %	JEWELER LATHE Hrs	JEWELER LATHE %	JIG BORER Hrs	JIG BORER %	TOOL CRIB Hrs	TOOL CRIB %	RECORDED HOURS	ADJUSTED HOURS	RATINGS ASSIGNED Always	Generally	Never
1	796	25	1115	43	318	9	52	1	168	5	96	3	84	2	479	12											3108	3108			X
2	358	18	324	16	100	5			214	10	159	7	108	5	694	34	103	5									2060	1997			X
3	136	6	226	10	90	6					37	1	665	32	753	35	209	10									2116	1920			X
4	205	10	1084	45	40	1			107	5	44	1			689	25	178	7	52	2	18	1	51	2			2468	2468			X
5	459	23	521	26	93	4			249	13					552	27	139	5									2013	2208	X		
6	694	32	209	9	37	1			323	15	65	2			207	10	681	31									2116	2120			X
7	38	1	252	13					92	4					904	43	709	35							99	4	2094	2028	X		
8	232	12	449	23	42	2			126	6	8	1	104	6	395	21	552	29									1908	1908			X
9	843	34	676	27	88	3			179	8	49	1	71	2	518	20	127	5									255[illegible]	2989			X
10	318	11	366	14	51	2			311	11					379	30	408	32									1833	1892		X	
11	490	24	30	1	1121	55			132	6							296	14									2069	2069		X	
12	498	21	141	6	79	3			19	1			10	1	651	27	963	41									2361	2361		X	
13	368	16	169	7	88	3			104	5					952	40	688	28	33	1							2402	2402			X
14	630	25	303	11	697	27			18	1	10	1	264	10	537	21	106	4									2565	2565			X
15	311	13	431	19	260	11			212	9	80	3	87	3	613	27	298	13	69	2							2361	2361		X	
16	374	16	326	14	57	2			44	1	52	2	40	1	1245	53	279	11									2417	2437		X	
17	559	23	475	20			14	1	47	2	26	1	73	3	948	42	206	8									2348	2348			X
18	901	32	820	29	10	1					59	2	144	5	817	30	52	1									2803	2803			X
19	301	14	560	28	529	33									419	20	106	5									2015	2015			X
20	181	7	763	34	42	1					31	1	18	1	538	24	732	32									2305	2329			X
21	125	4	252	20	313	11					306	11	161	5	811	30	123	4							345	15	2764	2891			X
22	155	6	353	14	1006	45	185	7			352	14	59	2	263	10	57	2									2430	2430			X
23	241	13	492	28	72	3			148	6	188	10	104	5	322	20	153	8	103	5							1823	2048			X
24	565	26	1120	55	84	3					29	1	28	1	195	9	107	5									2128	2128			X
25	152	8	632	32	20	1			123	5	57	2	40	1	792	40	155	7	95	4							2066	1918			X
26	285	10	480	18	1259	49							26	1	263	10	290	12									2603	2603			X
27	750	34	1173	56							6	1			187	8	34	1									2150	2150	X		
28	252	10	446	18			29	1			24	1	270	11	915	39	435	20									2371	2371			X
29	726	35	749	36	7	1			388	18	5	1	26	1	83	3	106	5									2090	2090			X
30	439	18	204	8	114	4			20	1			33	1	1262	55	335	13									2413	2413		X	

APPENDIX K

APPENDIX L

AVAILABLE RELATED RESEARCH DATA

I DEMOGRAPHIC AND EXPERIENTIAL DATA

A. Previous Associated Training
B. Previous Associated Experience
C. Age
D. Level of Education
E. Disadvantaged/Non-Disadvantaged
F. Marital Status
G. Military Status
H. Number of Dependants

II PERFORMANCE DATA (OBJECTIVE)

A. First Year Technical Proficiency Test

1. entry level
2. mid-term
3. final
4. 1 ▲ 2 ▲ 3

B. Mechanical Comprehension Test

1. entry level
2. mid-term
3. final
4. 1 ▲ 2 ▲ 3

III PERFORMANCE DATA (SUBJECTIVE)

A. Employee Performance Evaluation
B. Student Practical Application Rating System
C. Class Test Report, Blueprint
D. Class Test Report, Math

The above data, either on an individual or combined basis is available for any of the classifications of students in (1) above.

APPENDIX M

BACKGROUND DATA ON 16-WEEK PROGRAM DROP-OUTS

Total Students: 704

Completed: 436 (62%)

*Dropped: 268 (38%)

Background Data:	Total	Completed	Dropped
Associated Training	230	150 (65%)	80 (35%)
Associated Experience	242	151 (62%)	91 (38%)
Disadvantaged	265	148 (56%)	117 (44%)
Married	272	158 (58%)	114 (42%)
Military Service	323	189 (59%)	134 (41%)
Pairings			
Associated Training/Associated Experience	197	151 (77%)	46 (23%)
Disadvantaged and Military Service	123	71 (58%)	52 (42%)
Disadvantaged and Married	89	48 (54%)	41 (46%)
Military Service and Married	138	84 (61%)	54 (39%)

*Drop-outs based on those students from whom information cannot be obtained. No follow-up was made to determine reasons for drop-out or eventual occupation which they entered, due to contractual constraints. This category simply indicates that no cooperation was possible, due to company dictates, student attitudes, or student leaving for another job.

APPENDIX N

RESEARCH STUDENTS DROP-OUTS

Group I			Group II		
*Selected	90	100%	*Selected	92	100%
**Dropped	44	49%	**Dropped	38	41%
Retained	46	51%	Retained	54	59%

*Indicates number of students initially selected for each group.

*Drop-outs based on those students from whom information cannot be obtained. No follow-up was made to determine reason for drop-out or eventual occupation which they entered, due to contractural constraints. This category simply indicates that no cooperation was possible, due to company dictates, student attitudes, or student leaving for another job.

GLOSSARY OF TERMS

Apprentice - Any company employee registered in a State or Bureau of Apprenticeship & Training approved training program, usually for a period of four years, leading to certification as a journeyman.

Apprenticeship Program - Any State or Bureau of Apprenticeship and Training approved four-year program culminating in journeyman status for the apprentice.

Apprenticeship Standards - State or Bureau of Apprenticeship & Training approved criteria for the apprenticeship training program, usually expressed in hours per machine. Generally submitted by the apprentice's employer as guidelines which he will follow in training the apprentice.

Exposure Time - Exposure time is the total hours worked by an apprentice on a given set of basic machine tasks. The total hours worked on the given tasks do not directly reflect learning capability and/or competency in and of itself. The exposure time encompasses a subjective judgment/evaluation by a journeyman of the apprentice's capability at random times during the performance of the tasks. The evaluation is not based on a set of pre-ordained criteria, but on the particular specification of the task being accomplished.

Group I Research Students - Those students in the research program who record learning time as defined by performance criteria.

Group II Research Students - Those students in the research program who record total time spent on a specific task. This group is matched to the Group I in demographic and performance data obtained during pre-employment training.

Disadvantaged - A classification of individuals determined by the Bureau of Employment Security, based on a prescribed formula encompassing such factors as income, minority classification, age, education, etc.

Four Basic Machines - Within the tool, die and precision machining industry, the drill, mill, lathe, and grinder.

Journeyman - The tital accorded an apprentice who has completed a four-year indentureship in accordance with the prescribed criteria.

Learning Time - Learning time is the total hours necessary to successfully accomplish a criterially defined work-performance scenario, per machine-task, three (3) times, within a constrained work-performance-measurement demonstration time parameter which has been deemed "reasonable" by a journeyman observer/evaluator.

On-Job-Training - That phase of apprenticeship training, exclusive of formal related training classes, which usually follows the pre-employment training program.

Pre-Employment Training Program - An intensive 16-week training program designed to provide the student with the rudiments of knowledge and skill in the precision machining industry.

Prior Related Experience - Work experience, accrued prior to the pre-employment training program, relating either generally or specifically to the precision machining industry.

Prior Associated Training - Formal or semi-formal training, accrued prior to the pre-employment training program, relating generally or specifically to the precision machining industry.

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