THE DEVELOPMENT OF A DECISION MODEL FOR STATEWIDE MANPOWER PLANNING RELATED TO VOCATIONAL AND TECHNICAL EDUCATION

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PREFACE

This dissertation was based upon the idea that the application of quantitative techniques, presently used by the industrial engineers, would be appropriate for use by the managers of the vocational and technical education system in their decision process. The approach was to study the vocational and technical education system in an effort to determine the extent of commonality between industrial production systems and the vocational and technical training system. Once the commonalities and differences were identified, a decision model was developed to meet the needs of occupational training in Oklahoma.

The literature search revealed that quantitative methods were not extensively used during the decision process by vocational and technical education administrators. It was found that quantitative data required for effective decisions was not available prior to the development of the Occupational Training Information System. The usual approach to decision making was to make a qualitative assessment based upon personal experience, tradition, or authority. By contrast, this investigation generated a model which identifies the type of data needed for the rendering of effective decisions. The application of the

model provides a systematic method for evaluation which heretofore did not exist.

I would like to express my deep appreciation and sincere thanks to the following members of my committee: Dr. James E. Shamblin, Chairman, for his over-all guidance and valuable assistance in all stages in the development of this study and for his detailed direction, encouragement, and understanding whenever needed; Professor Wilson J. Bentley for his encouragement, understanding, and assistance; Dr. Gladstone T. Stevens, Jr., for being constantly available to help with any problem and his detailed assistance in the development of the control model; Dr. Paul V. Braden, for providing resources and guidance in the area of vocational and technical education and for helping define the problem area in this study; Drs. Earl J. Ferguson and William W. Rambo for their interest and assistance.

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CHAPTER I

INTRODUCTION

Vocational and technical education has received an increasing amount of attention since the passage of the Smith-Hughes Act in 1917. The U. S. Congress has appropriated federal funds to the states for vocational education every year since 1917. The most recent legislation, the Vocational Education Amendments of 1968, is partly aimed at providing federal assistance to states in order to maintain, extend, and improve existing programs of vocational education; also to begin new programs which are of high quality and are realistic in the light of actual or anticipated opportunities for gainful employment. At the time of this writing, the authorized appropriation of federal funds for fiscal years 1969 through 1973 is approximately 2.84 billion dollars (1). The combination of federal, state, and local funds anticipated to be expended for vocational education during this period exceeds six billion dollars.

The U. S. labor market is presently undergoing a rapid change. New types of industries are emerging, the participation rate of females is increasing, the mobility patterns of workers are varying, and there is more concern for improving the labor market position of the poor, disadvantaged, and the unemployed. Because of the multitude of multifarious individuals who will be affected by the decisions made by the administrators of the complex vocational education system, it is imperative that a rational, systematic, continuous, evaluation procedure be developed to increase the probability of attaining the desired outcomes or benefits, consistent with the monetary resources which must be expended for securing these benefits.

Purpose of the Study

The purpose of the study is to develop a decision model that describes the vocational and technical education system which can be used to formulate mathematical procedures to aid in more meaningful decision making for statewide manpower planning in Oklahoma. The model will provide a framework for classifying data obtained from the various sources being utilized by the Occupational Training Information System (OTIS) in the State of Oklahoma (2). A systematic procedure will be developed to identify the activities which are inherent in the vocational and technical education system. These activities will be arranged in a formal and logical manner so that a proper evaluation can be conducted by the directors of the vocational and technical education system during the decision making process. Operational definitions will be formulated and the variables defined for a clearer understanding of their significance as related to the system.

Specifically, this study will be concerned with the following research questions:

1. Can a decision model be developed which adequately describes the vocational and technical education system?
2. Can a model be developed which is acceptable to the many agencies which comprise the vocational and technical education system?
3. Can a model be developed which is within the resource capability of the state?
4. Can the activities of the system be identified and arranged in a sequential manner for analysis?
5. Can the variables be identified and their interrelationships be determined?
6. Can the variables be quantified with a degree of accuracy that will increase the probability of producing better decisions?

Background Information

Federal Legislation

The growing industry of the U. S. in the early twentieth century exhibited an increased demand for skilled manpower. Immigration laws were becoming more restrictive and the nation's supply of skilled workers migrating from Europe was diminishing. The need for skilled workers was becoming acute. It was in this climate that the Commission on National Aid to Vocational Education was created by an act of Congress in 1914 (3, pp. 82-89).

A doctoral dissertation by Mary Louis Ellis titled, "A Synthesis of Activities Leading to the Enactment of the Vocational Education Act of 1963," provides a chronology of the events leading to the passage of the Vocational Education Act of 1963. The following federal legislation are the more important statutes which affected the growth of vocational and technical education in the United States (4, pp. 16-28).

The Smith-Hughes Act of 1917 was designed to promote vocational education in the fields of agriculture, home economics, trades and industry, and for teacher training in these fields. It also provided for a permanent federal appropriation of $7.1 million annually with a stipulation of dollar-for-dollar matching by state and/or local funds. This act created the Federal Board for Vocational Education (5, p. 67).

The George-Reed Act of 1929 was the result of joint efforts by the leaders of vocational agriculture and home economics to amend the Smith-Hughes Act so that appropriations for home economics could be separated from the appropriations for trades and industry programs thereby making it possible to expand services in the field of home economics. This was a temporary measure due to expire in 1934 (5, p. 68).

The George-Ellzey Act of 1934 replaced the George-Reed

Act of 1929 and provided for the further development of vocational programs for agriculture, home economics, and trades and industry. A $3 million annual appropriation was made to be divided equally among agriculture, home economics, and trades and industry (5, p. 68).

The George-Deen Act of 1936 not only provided continued support for vocational education programs in the fields of agriculture, home economics, and trades and industry but included federal support for the first time for the field designated as distributive occupations (5, p. 71).

The Defense Training Act of 1940 provided for the training of manpower for national defense purposes. The first year's appropriation for the war production training program was $15 million. Appropriations were expanded while the United States was engaged in World War II to more than $100 million annually (4, p. 23).

The George-Barden Act of 1946 amended and superseded the George-Deen Act. Authorizations for appropriations were increased to $29 million annually and the fifty-fifty matching of funds provision was retained. The fields for which authorization for appropriations were made included the program areas of agriculture, home economics, trades and industry, and distributive education. This legislation also made it legal to use funds for occupational information and guidance (4, p. 24).

The Health Amendments Act of 1956 provided for appropriations of $5 million annually for five years for grants to the states for practical nursing training. The act provided that the federal government would pay 75 per cent of the costs for practical nurse training for the fiscal years ending June 30, 1957 and June 30, 1958 and 50 per cent of such costs for each of the three succeeding fiscal years (6, p. 95).

The National Defense Education Act of 1958 amended the George-Barden Act of 1946. The amendment authorized appropriations of $15 million annually until June 30, 1962, for area vocational education programs designed to meet the national defense needs for highly skilled technicians. The area concept in vocational education to establish schools which would serve beyond the geographic boundaries of one school district had evolved (4, p. 26).

The Area Redevelopment Act of 1961 provided $4.5 million for training and retraining of unemployed workers who lived in designated redevelopment areas. This act was temporary and scheduled to expire on June 30, 1965 (7).

The Manpower Development and Training Act of 1962 provided funds for training and retraining underemployed and unemployed individuals to develop skills needed for employment. The act was designed to be jointly administered by the U. S. Departments of Labor, and Health, Education, and Welfare. The amount of the authorized appropriation was $161 million annually for three years and was scheduled to terminate on June 30, 1965. This act was designed to deal with the problems of unemployment resulting from automation and technological changes and other types of persistent unemployment (8).

The Vocational Education Act of 1963 was perhaps the most important piece of legislation affecting the area of vocational training to date. This act represented a departure from previous vocational legislation in that it focused upon groups of people to be served rather than categorical assistance for specific vocational education fields. The 1963 Act focused on the need to provide training for youth and adults who had academic or socio-economic handicaps. It was responsive to the embryonic civil rights movement in that the Act stated in its purposes that persons of all ages in all communities of a state should have ready access to vocational training which was realistic in the light of actual or anticipated opportunities for gainful employment (9).

The Vocational Education Amendment of 1968 repealed all prior vocational education acts with the exception of the Smith-Hughes Act. This act was broader in scope than any legislation passed to date. It included programs for the disadvantaged, handicapped, adult education, and all others who express a need for vocational education. Appropriations were made for special manpower studies, research, and training in vocational education, school construction, curriculum development, teacher training and others. The federal matching formula concerning funding was also changed (1).

TABLE I

SUMMARY OF VOCATIONAL AND TECHNICAL EDUCATION LEGISLATION

YEAR	LEGISLATIVE TITLE	HIGHLIGHTS
1917	Smith-Hughes Act	First act providing federal aid for vocational education.
1929	George-Reed Act	Promoted further development of agriculture, home economics, and trades and industry.
1934	George-Ellzey Act	This was an extension of the George-Reed Act.
1936	George-Deen Act	Included federal support to a new vocational field designated as distributive education.
1940	Defense Training Act	Provided for education related to national defense industries.
1946	George-Barden Act	Amended and superseded the George-Deen Act and legalized the use of funds for occupational information and guidance.
1956	Health Amendments Act	Authorized appropriations for practical nursing training.
1958	National Defense Education Act	Authorized appropriations for programs designed to meet the national defense needs for highly skilled technicians.
1961	Area Redevelopment Act	Provided funds for the training and retraining of unemployed workers living in designated redevelopment areas.
1962	Manpower Development and Training Act	Provided funds for training and retraining individuals unemployed or underemployed.
1963	Vocational Education Act	Focused national attention on vocational education. Focused on groups of people rather than categorical vocational education fields.
1968	Vocational Education Amendment	Vastly broadened the scope of vocational education.

<u>Challenges to Vocational Education</u>

The vocational-technical education systems in Oklahoma and the nation are facing new challenges. Some of the crucial changes causing these challenges listed in recent studies are:

1. The revolutionary discoveries in science and technology.
2. The decreases in unskilled jobs and increases in semi-skilled, skilled, and technical categories.
3. The disappearance of many traditional jobs, while complex machines and processes are creating new ones.
4. More trained manpower are needed at a faster rate than the public and private institutions can supply.
5. Changes in industry, business, and agriculture require additional highly trained workers as well as the retraining of those whose skills have become obsolescent (10, p. 1).

Maurice Roney and Paul Braden maintain that only through a reconciliation of training institutions keyed to the changing occupational requirements and the development of human resources can an economy be prevented which is characterized by job openings requiring educated and skilled people, and, at the same time, a body of unemployed and underemployed, too poorly trained to make a contribution to the technological economy (10, p. 2).

Gerald Somers supports the statements of Roney and Braden. According to Somers, if Vocational Education has become the whipping boy of the 1960's, the focal point of the attack is clearly its lack of responsiveness to an ever changing labor market (11, p. 32). The major labor market changes reported by Somers were:

1. A marked shift from employment in agriculture and other primary industries to the so-called tertiary industrial sector - service industries and especially government.
2. A revolutionary increase in the labor force participation of women, especially married women - a movement from the home to employment.
3. A marked occupational shift from manual, unskilled work to white-collar, professional and technical skills.
4. A continuing shortage of highly skilled craftsmen and a growing number of complaints about the inadequacy of the apprenticeship system.
5. A growing recognition of the mobility of American workers, between geographic areas, between industries and between occupations.
6. An increasing concern with the labor-market position of the disadvantaged and the unemployed.

Evaluation Effort

A recent study by Jerome Moss Jr. concerned itself with the procedures and methods used by vocational administrators for evaluating occupational education programs (12). His justification for the study was based upon the validity of the following three assumptions:

1. Program evaluation is essential to systematic improvement in educational efficiency and effectiveness.
2. An intensification of evaluative activity is highly desirable.
3. Much of what little has been done to date in the name of program evaluation is of questionable usefulness (12, p. 1).

Moss was highly critical of the lack of systematic, quantitative procedures used in arriving at decisions made by vocational administrators.

Moss maintains that inactivity in evaluation of occupational education programs has been demonstrated by the fact that relatively few evaluative studies have been conducted since the passage of the Vocational Education Act of 1963. Philosophical-political, a shortage of vocational and technical researchers, and the complexity of the computational techniques were given as the primary causes of this inactivity (12, p. 3).

According to Moss:

Evaluation is essential to the development of a

> science of instruction without which we shall continue to operate by hunches, authority, tradition, and personal experience. From now on, however, the picture must change. The advisory council on vocational education has demanded greater efforts at evaluation. Social scientists from a wide variety of disciplines are turning their attention to the assessment of various systems of manpower training. Our social obligation for evaluation is being assumed by others, and the results could determine our very existence. We must evaluate our own programs using appropriate criteria and methodology so that decisions concerning our future can be based upon data which properly reflects our educational perspectives (12, p. 3).

The wisdom of the prophecy by Moss regarding scientists from a wide variety of disciplines turning their attention to fields which were heretofore considered unrelated can be seen by noting the remarks of J. O. Grantham in an address given before the 34th annual meeting of the Oklahoma Society of Professional Engineers in Oklahoma City on Friday, April 25, 1969 (13).

J. O. Grantham, who is a professional engineer, lauded the scientific method and expressed the need for seeking answers based only on the right numbers to move to a high point in human life (13, pp. 1-2). He said:

> We seem to be reaching a point in our national and international affairs where reason, fact, analysis, synthesis and other problem solving terms are being replaced by emotion, feeling, irrationality and an almost compulsive desire to ignore what really is and conjure up in our mind what we wanted it to be (13, p. 2).

His thesis is that within the engineering discipline and the engineering approach to problem solving is an answer to rational solutions to social problems. The only major hurdle to overcome to do this is "the instinctive irrational approach that that we all take to solving social problems" (13, p. 3).

Although Grantham's talk concerned itself with the contribution that engineers and the use of engineering principles could make to aid in finding solutions to today's urban crisis, also included was a field which he described as social engineering which could be deemed as appropriate for including vocational and technical education which might also be improved if engineering principles were applied in an appropriate manner to assist in rational, systematic decision making.

A review of existing literature in the field of vocational and technical education confirms the assertions of Braden, Roney, Somers, and Moss that few evaluative studies have been conducted to this period of time. The majority of studies which have been concluded were related to qualitative assessments of the many variables which comprise the vocational education environment. This has been a very fragmentary approach to the evaluative process. There have also been some very broad studies which attempt to determine the value of vocational education compared to some other educational or training program utilizing the "alternative cost doctrine" or the "opportunity cost doctrine." This doctrine states that the supplies of economic resources in the economy are limited in relation to human wants, when resources are used by a firm in the production of a product, certain quantities of other products which those resources aid in producing must be foregone by society (14, p. 136).

The U. S. Department of Health, Education, and Welfare conducted a study which compared vocational education with academic education in an effort to evaluate comparative costs and benefits of both educational systems (15). The conclusion was that vocational-technical education, when compared with other curricula, has a "pay-off" in terms of earnings and employment. What has been suggested is that training youth for jobs should be expanded if there is a concern with earnings and employment. This expansion should include an investment either by reallocating existing educational resources or by additional expenditures in training youth in broad occupational programs as well as in traditional vocational programs (5, p. 156).

A Need for More Planning

Ample evidence has been provided by leaders in the vocational and technical education system to support the need for a continuous information and evaluation system for occupational training. This must be consistent with the benefits or outcomes desired and the resources which must be expended for securing these benefits (Benefits vs. Burdens).

Harold Starr states that an evaluation methodology which has greater payoff for state vocational education agency program planners is a methodology which is oriented primarily toward product or outcome measures and which is consistent with a systems approach to planning (16, p. 5).

James W. Altman reports that deciding what to teach is no longer casual or obvious. It is becoming an increasingly expensive and complex process, albeit one which is still largely implicit and lacking a generally accepted technological base (17, p. 2). No educational development effort has unlimited resources of manpower, money, materials, facilities, or time. Each has additional political, technological, instructional staff, policy and administrative limits (17, p. 5).

Edward B. Jakabauskas relates that effective vocational and technical educational planning involves choice among alternative occupational training programs; it involves an evaluation of capabilities and capacities of trainees; and it involves a very complex matching process between occupations and workers. To obtain and utilize manpower data, more effective coordination among disciplines within the academic community is needed, as well as between the academic community and action-agencies responsible for carrying out programs in manpower and related fields (18, p. 2).

A methodology or procedure for making analyses should be formulated such that, when the alternative cost doctrine analysis has been completed and an allotment of funds has been made available for vocational education, these funds will be utilized in the most effective manner.

The need for statewide manpower planning must first be recognized before any procedures can be developed and implemented to gain greater management efficiency in directing the vocational and technical education complex. The Vocational Education Amendments of 1968, P.L. 90-576, makes it mandatory for any state desirous of receiving federal funds for vocational education to demonstrate that they have considered the total statewide manpower environment by the submittal of their state plan for the administration of vocational education to the federal government for approval. Many states are concerned with meeting the requirements for statewide manpower planning in relationship to public vocational education, if for no other reason but to qualify for federal funds. Some states are actively trying to conceptualize, design, and operate a system for greater manpower utilization (2) (16) (17) (18). The State of Oklahoma is one state which by its action is a leader in this new challenging era.

Strategy Requirement

In the spring of 1968, representatives from the Research Department of the Industrial Development and Park Department, the State Department of Vocational and Technical Education, and the Oklahoma Employment Security Commission met to discuss the need for a statewide research and demonstration project which could bring maximum resources to bear on implementing a strategy for economic development which had as its major premise the development of a skilled labor force. Subsequently, the Manpower Research and Training Center at Oklahoma State University was approached to react in detail as to the feasibility of such a project (10).

In July of 1968, a proposal was submitted to the concerned agencies, whereupon the State Department of Vocational and Technical Education and the Industrial Development and Park Department agreed to preliminary funding of the project with cooperation provided by the Oklahoma Employment Security Commission and the private schools. The over-all purpose of this project was to develop and initiate a systematic, continuous and detailed occupational training information system (OTIS) as a better data base for encouraging changes in Oklahoma's State Plan for Vocational Education and in consequent patterns of occupational offerings and enrollments (2). To accomplish its objectives, OTIS was divided into six subordinate subsystems; namely,

(a) Manpower Supply Subsystem
(b) Manpower Demand Subsystem
(c) Cost Subsystem
(d) Graduate Follow-Up Subsystem
(e) Underdeveloped Human Resources Subsystem
(f) Socio-Political Subsystem.

A detailed system of this type is requisite for success in rendering meaningful, valid, manpower policy and operational decisions which are necessary for industrial growth in the economy of Oklahoma.

The Governor of Oklahoma has often stated publicly that one of his major objectives is to increase the general welfare of the citizens of Oklahoma by industrializing the

State. The two methods available for doing this is to expand industry presently located in the State, and to induce industries from without the State to locate in Oklahoma.

A strategy for economic development in Oklahoma was formulated by the Division of Research and Planning of the Industrial Development and Park Department.

> The fundamental objective of this economic development is to create more and better jobs and income for the people of Oklahoma and to increase the internal growth of Oklahoma's economy. ... This program is oriented towards the development and growth of the economy of Oklahoma through financial investments directed towards large, new income generating activities. ... Our strategy for economic development indicates the activities necessary and relevant for generating and raising new real income in Oklahoma. ... Information, careful, detailed, systematic, up-to-date and operational information, is totally necessary on demand, supply and marketing factors. ... The economic development program must help create establishments which will employ many people. Further, the resources, so committed to economic development must be invested effectively so that Oklahoma can rapidly grow in the capability to increasingly finance more of its own development out of the increased productivity and earnings of its citizens. ... The principle objective is to assure the effective, rapid growth of Oklahoma's market penetration and productive capabilities. Considerations of this type must involve evaluations of what should be done and in what order and in what size (19).

The Fantus Company completed an industrial location appraisal for selected areas of the State of Oklahoma. In discussing the forces affecting the future development of the State, the need for skilled manpower was emphasized as a primary factor in industrial development (26, p. 11).

Sources of Skilled Manpower

The strategy for the economic development of Oklahoma seems to be a sound one. The degree to which it will succeed is largely dependent upon the cooperation and contribution of other state and private agencies whose outputs are required. This study is limited only to the required output of trained manpower and does not consider other requirements for the success of the strategy. The sources of supply available to satisfy Oklahoma's demand sector considered are:

(1) Full-time public vocational and technical education.

(2) Adult public vocational and technical education.

(3) Manpower Development and Training Act graduates (MDTA).

(4) Private schools.

(5) Other, comprised of industrial on-job-training and registrants at the Oklahoma Employment Security Commission.

These sources provide trained manpower for the total supply of human resources available to meet the demands of the employment sector for trained workers (2, p. 19).

The public full-time training programs represent the major portion of publicly supported manpower supply and it is this sector which is the most responsive to statewide manpower control in the State of Oklahoma. This study will relate primarily to vocational and technical public full-time training programs.

The State Department of Vocational and Technical Education determines the full-time public training programs that will be established for providing the trained manpower available to meet the demands of the Oklahoma occupational sector. The degree to which the programs train personnel with the skills to match the employment sector's need for this type of skill will directly affect the number of graduates who can acquire gainful employment in occupations related to their training and enhance the economic growth of Oklahoma.

Objectives of Public Vocational and Technical Education

The State Department of Vocational and Technical Education of Oklahoma designed and submitted a Plan for the Administration of Vocational Education and lists the objective of instruction as:

(1) Vocational instruction shall be designed to:

(a) prepare individuals for gainful employment as semi-skilled or skilled workers or technicians or subprofessionals in recognized occupations and in new or emerging occupations, or

(b) prepare individuals for employment in advanced or highly skilled vocational and technical education programs, or

(c) assist individuals in the making of informed and meaningful occupational choices, or

(d) achieve any combination of the above objectives.

(2) Vocational instruction with the objective specified in sub-paragraph (1)(a) shall include

(a) instruction related to the occupation or occupations for which the students are in training; that is, instruction which is designed upon its completion to fit individuals for employment in a specific occupation or a cluster of closely related occupations in an occupational field, and which is especially and particularly suited to the needs of those engaged in, or preparing to engage in, such occupation or occupations. Such instruction shall include classroom related academic and technical instruction and field, shop, laboratory, cooperative work, or other occupational experience, and may be provided either to

(i) those preparing to enter an occupation upon the completion of the instruction, or

(ii) those who have already entered an occupation but desire to upgrade or update their occupational skills and knowledge in order to achieve stability or advancement in employment.

(b) instruction necessary for vocational students to benefit from instruction described in subdivision (a); that is, remedial or other instruction which is designed to enable individuals to profit from instruction related to the occupation or occupations for which they are being trained by correcting whatever education deficiencies or handicaps that prevent them from benefiting from such instruction.

(3) Pre-technical vocational instruction with the objective specified in subparagraph (1) (b) shall include instruction of the type described in subparagraph (2) of this paragraph, except that such instruction need not be designed to fit individuals for employment in a

specific occupation, but must be primarily designed to prepare individuals for enrollment in advanced or highly skilled post secondary and technical education programs having the objective specified in subparagraph (1) (a) of this section. It shall not include instruction which is primarily designed to prepare individuals for higher education, or for professional training of the type described in (2) of this section, and which is only incidentally designed for individuals preparing for technical education.

(4) Pre-vocational instructions with the objectives specified in subparagraph (1) (c) shall include instruction designed to familiarize individuals with the broad range of occupations for which special skills are required and the requisites for careers in such occupations (21, pp. 40-42).

Recently completed studies relevant to vocational and technical training indicate the need for matching the training program with job opportunities available in Oklahoma and for making the available opportunity known to the potential employee. One study reported that Oklahoma employer representatives and school placement officials are not communicating effectively (22). This lack of communication may be a causal factor for the large number of trained personnel who out-migrate to accept employment or who accept employment in Oklahoma in jobs non-related to their training. It is reported that graduates in many program service areas are being employed in occupations other than those for which they were primarily trained (23). Roney and Braden (10) state that the majority of technician training graduates who outmigrate (approximately one-half of those who take jobs immediately after graduating) would prefer to stay in

Oklahoma if equal job opportunities were available. An analysis of data supplied by the Oklahoma Occupational Training Information System staff showed that the percentages of Oklahoma graduates placed in jobs related to their training both within and without Oklahoma ranged from a low of 11 per cent in Home Economics (Gainful) to a high of 68 per cent in the Health Occupational Division.

Implications

There are certain implications which can be stated from the material presented thus far in the study. These include:

1. The literature regarding vocational and technical education is largely descriptive in nature and tends toward generalization rather than systematic development of models or techniques which can use empirical data to aid in decision making.
2. The vocational and educational system is an important source of trained manpower and is a critical variable relative to industrial development.
3. Oklahoma's labor force has undergone a rapid change in size, composition and the need for a variety of skilled manpower.
4. Effective communication between industrial representatives and placement officials is lacking.

5. Graduates are accepting employment in occupations not related to their training.
6. Most technical graduates who out-migrated from Oklahoma would have preferred to remain in Oklahoma if equal job opportunities were known to be available.
7. The Governor and other high officials have recognized a need for the economic development of Oklahoma and have formulated a strategy to increase the economic growth of the State.
8. The State Department of Vocational and Technical Education has developed a plan for the administration of the vocational and technical education system which is in accord with the strategy developed for economic growth.

Relationship of Trained Manpower to Economic Development

Figure 1 depicts the relationship of skilled manpower development by the vocational and technical education system to the Oklahoma strategy for economic growth and the eventual betterment of its citizens. This figure schematically shows that to achieve the objective of increasing the general welfare of the Oklahoma populace requires many different strategies, one of these is the Industrial Development and Park Department strategy (IDPD) for the industrial growth of the economy. The IDPD strategy requires resources

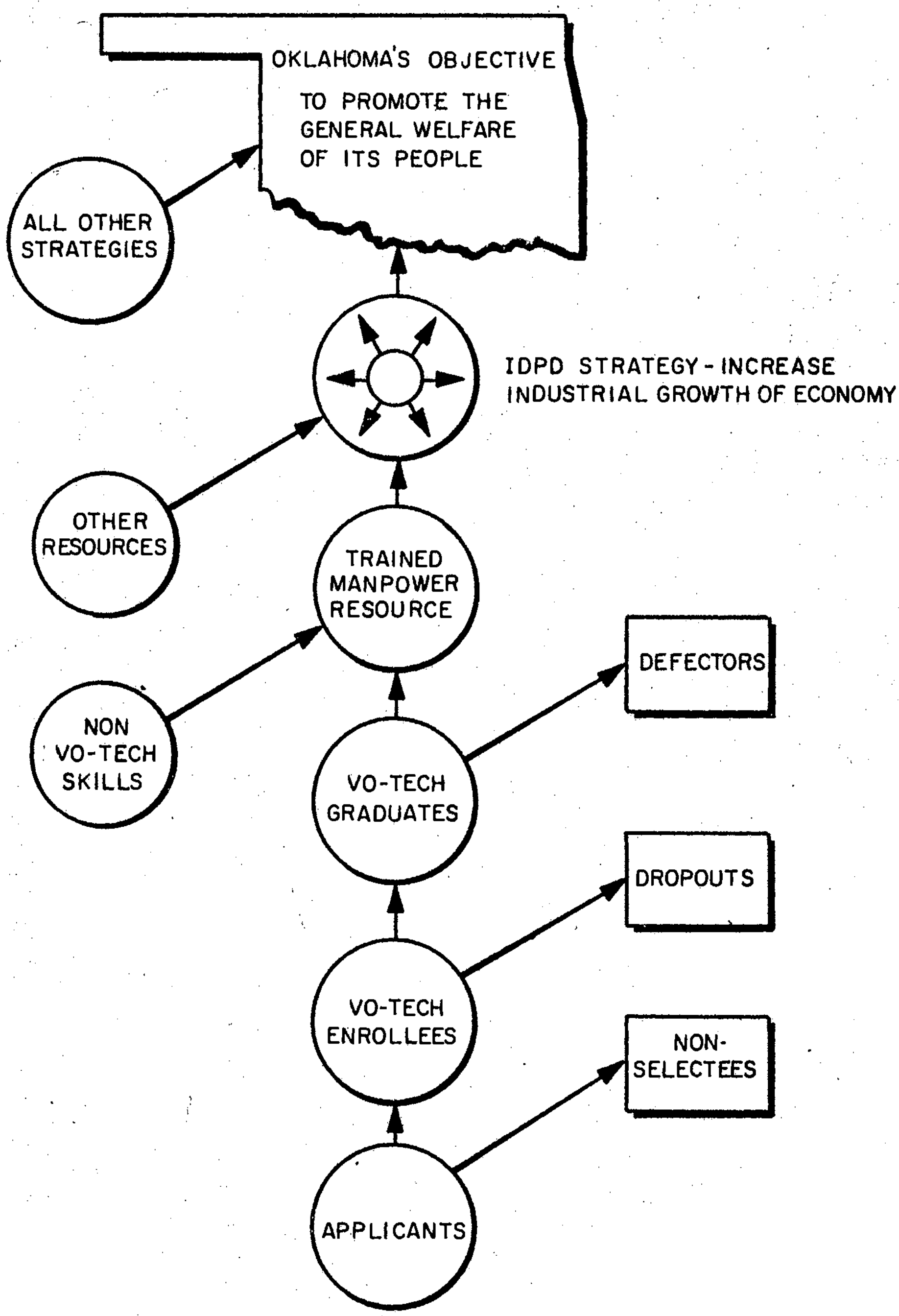

Figure 1. The Relationship of Skilled Manpower Development by the Vocational and Technical Education System to Oklahoma's Strategy for Economic Growth

of a monetary, material, and manpower nature. The available trained human resources are supplied from the vocational education and training system plus other non-vocational-technical sources. Not all vocational-technical graduates are available for employment because some out-migrate, enter the military, continue schooling, and so forth. The number of graduates of the system is dependent upon the number of enrollees and the number who dropout of the program. Enrollments are dependent upon the amount of money, physical facilities, and applicants available.

Definition of Terms

The following definitions of terms pertaining to vocational and technical education are listed to help the reader gain a greater understanding of this training system.

> <u>Vocational Education</u> - Vocational or technical training or retraining which is given in schools or classes (including field or laboratory work and remedial or related academic and technical instruction incident thereto) under public supervision and control or under contract with a State board or local educational agency and is conducted as part of a program designed to prepare individuals for gainful employment as semi-skilled or skilled workers or technicians or subprofessionals in recognized occupations and in new and emerging occupations or to prepare individuals for enrollment in advanced technical education programs, but excluding any program to prepare individuals for employment in occupations which the Commissioner determines, and specifies by regulation, to be generally considered professional or which requires a baccalaureate or higher degree (1, p. 67).

> <u>Special Needs Vocational Training</u> - Vocational training provided for those persons who have

been identified as being disadvantaged or handicapped (21).

Non-Special Needs Vocational Training. Vocational training provided for those persons who have not been identified as being disadvantaged or handicapped (21).

Disadvantaged Persons - Are those persons who have academic, socio-economic, cultural, or other handicaps that prevent them from succeeding in vocational education or consumer and homemaking programs designed for persons without such handicaps, and who for that reason, require specially designed educational programs or related services. The term includes persons whose needs for such programs or services result from poverty, neglect, delinquency, or cultural or linguistic isolation at large but does not include physically or mentally handicapped as defined under the "handicapped term" later defined, unless such persons also suffer from the handicaps described in this definition (21, p. 48).

Culturally Disadvantaged - Pupils whose cultural background is so different from that of most pupils that they have been identified by professional personnel as needing additional educational opportunities beyond those provided in the usual school program if they are to be educated to the level of their ability. The National Committee on Employment of Youth states 'Most of the population today considered (culturally) disadvantaged are the minority groups - Negroes, Puerto Ricans, Mexican-Americans, Indians, Cuba refugees, Appalachian whites and the nations' poor migrant laborers' (24, p. 181).

Economically Disadvantaged Students - Students from homes with less than three thousand dollars of annual income.

Handicapped Persons - Are those persons who are mentally retarded, hard of hearing, deaf, speech impaired, visually handicapped, seriously emotionally disturbed, crippled, or other health impaired persons who by reason of their handicapping condition cannot succeed in a vocational or consumer and homemaking education program without special educational assistance or who require a modified vocational or consumer or homemaking education program (1, p. 9).

Secondary Vocational Training - Refers to the general level of instruction provided for pupils up to grade 12 (24).

Post-Secondary Vocational Training - Vocational training beyond grade twelve, usually refers to the general level of instruction provided for pupils in college programs beginning with grade 13, and any instruction of a comparable nature and difficulty provided for adults and out of school youth (24).

Adult Vocational Training - Vocational training provided for adults and youth beyond age 16 or the age of compulsory school attendance in a separate adult educational arrangement with a school system, college or other public agency or institution (24, p. 118).

Occupational Training - Occupational Training is that training which prepares the student for sub-professional employment. It traditionally includes the following service divisions (24, p. 120):

a. Agriculture Education
b. Distributive Education
c. Health Education
d. Home Economics Education
e. Office Education
f. Technical Education
g. Trade and Industrial Education.

Agriculture Off-Farm Program - Subject matter and learning activities that are concerned with enabling a pupil to acquire knowledges and develop understanding attitudes and skills relevant to occupations which perform services for farmers; sell agricultural input material to farmers; or buy, process and distribute the farmer's product (24, p. 417).

Agriculture Production Programs - Subject matter and learning activities which are concerned with the principles and processes involved in the planning related to and the economic use of facilities, land, machinery, chemicals, finance and labor in the production of plant and animal products (24, p. 417).

Distributive and Marketing Program - Includes various combinations of subject matter and learning experiences related to the performance of activities that direct the flow of goods and services, including their proper utilization, from producer to consumer or user (24, p. 467).

Health Programs - Education for health occupations comprises the body of related subject matter, or the body of related courses, and planned experiences designed to input knowledges and develop understandings and skills required to support the health professions (24, p. 512).

Home Economics (Gainful) Programs - The group of related courses or units of instruction organized for purposes of enabling pupils to acquire knowledges and develop understandings, attitudes, and skills relevant to occupational preparation using knowledges and skills of home economics (24, p. 541).

Home Economics (Useful) Programs - The group of related courses or units of instruction organized for purposes of enabling pupils to acquire knowledges and develop understandings, attitudes and skills relevant to personal, home, and family life (24, p. 544).

Office Programs - Office Education Programs include the body of related subject matter, or related courses, and planned learning experiences which are designed to develop in pupils the attitudes, knowledges, skills, and understandings concerned with business principles and practices having applications for personal and/or activities in the business world (24, p. 606).

Technical Programs - Technical programs are concerned with that body of knowledge organized in a planned sequence of classroom and laboratory experiences, usually at the post-high school level, to prepare pupils for a cluster of jobs in a specialized field of technology (24, p. 638).

Trade and Industrial Programs - Trade and Industrial Programs is that branch of vocational education which is concerned with preparing persons for initial employment, or for upgrading or retraining workers in a wide range of trade and industrial occupations (24, p. 653).

Economic Benefits - Benefits derived from occupational training including employment received in an occupation related to the field for which the student is trained and the salary received for such employment.

Beginning Salaries - Salaries received by occupational training graduates when first entering employment (within three to six months after graduation).

CHAPTER II

FACTORS RELATED TO THE DEVELOPMENT OF THE DECISION MODEL

The evaluation methodology which has been most widely used by vocational education administrators is process evaluation which focuses upon assessing the adequacy of educational processes and organizational structures, equipment, and facilities. This type of traditional process evaluation methodology concentrates upon program standards rather than program outcomes (16, p. 1). However, information derived from carrying out such evaluation in the absence of product or outcome information is not usually suitable for assisting vocational educational agencies in the decision making tasks relative to state vocational education agency program planning or for meeting accountability requirements. To accomplish these two aims, the use of product or outcome oriented evaluation methods is required (16, p. 2).

Coordination in obtaining and utilizing meaningful manpower data involves teamwork among the various academic disciplines. There has been much written and discussed about the necessity for "coordination" in the manpower field, but very little specification of what goals coordination is to achieve, and at what cost (18, pp. 5-6). There are many aspects of research that have not as yet been developed, but hope to establish in the future. The most critical would be studies of changes in job content, research on internal rates of return for occupations, and most importantly the development of a system for evaluating the effectiveness of vocational education in meeting manpower needs (18, p. 13).

Braden in Oklahoma (2), Malinski in Minnesota (25), Morton in Texas (26), Starr in Ohio (16), Jakubauskas in Iowa (18), and Arnold in Pennsylvania (27) are actively attempting to develop a statewide manpower system which will improve the effectiveness of the manpower development effort. There is agreement among this group that a systematic approach is required. All have exerted great effort in planning to formulate a workable system for gathering the type of data needed for making manpower decisions. However, relatively little has been done to develop a decision model which identifies the variables, activities, and functions and shows their interrelationships. This may be partly due to the fact that only since the passage of the Vocational Education Amendments of 1968 has an active effort been exerted; therefore, system concept and development for statewide manpower planning and particularly the vocational and technical education system, is still in the infancy stage.

Factors Relating to the Model

The factors relating to the vocational and technical education decision model will be identified as a function, activity, or variable.

A function relates to the total system and implies broad power of control, administration, supervision, and objectives. The vocational and technical education system will be described as having two functional strata. These are the management function and the guidance function.

An activity relates to an entity which exists for a unique or specific purpose and whose power of control, administration and supervision is limited to the accomplishment of its designated task. The activities of the system are the recruiting activity, selection activity, training activity, and placement activity.

A variable relates to describing the state of the system during any period of time. The variables of the system will be discussed in a later section of this chapter.

Figure (2) depicts the factors for the vocational and technical education system considered in developing the decision model.

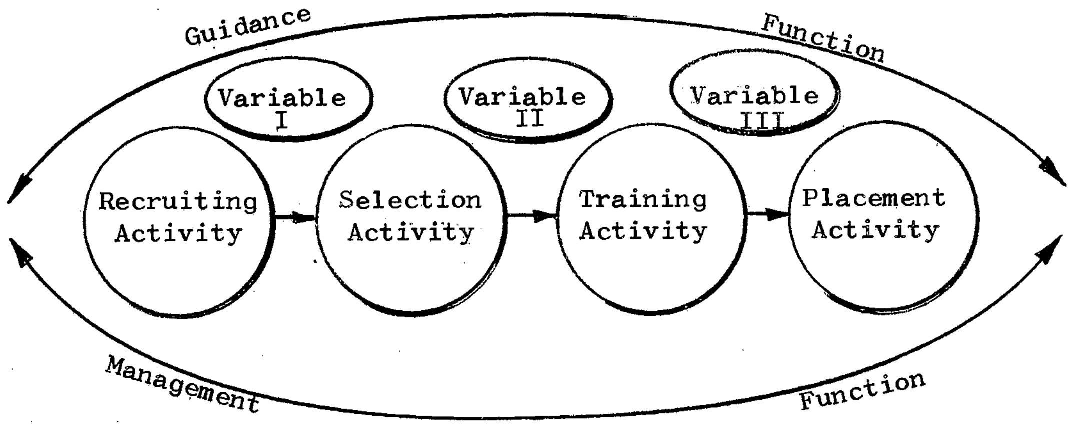

Figure 2. Factors Which Affect the Vocational and Technical Education System

Functions Relating to the Model

The vocational guidance function relates to the total system and is aimed at assisting the potential students to formulate their educational and vocational goals, to plan the achievement of these goals, and to manage their performance toward these goals (28, p. 1). The attitude of the general populace concerning vocational and technical education has been more negative than toward other educational systems. Vocational counselors often find that there are at least three interrelated factors adversely affecting student interest in vocational education (28, p. 1). First, vocational education programs are considered as a "dumping ground" for many school systems (29). Students unable to meet the demands of college preparatory or general education curricula are often counseled toward vocational education curricula (30). Second, many parents, teachers, and school administrators not directly involved in vocational education programs consider them "less respectable" than college preparatory programs (31). Third, students themselves frequently develop pejorative attitudes - probably conditioned to their parents and other adult models - toward vocational education teaching, and toward students and the values of terminal training programs (32). Because of this adverse attitude of the populace, the guidance function must be broad enough in scope to encompass all the activities inherent in the vocational education system is shown in Figure 2. Appendix A contains a list of 12 components which a comprehensive guidance system should contain. The basic objective of the guidance function is to aid the individual achieve his goal as a human specie with a variety of wants, needs, and desires from life. This is a continuous function being performed during every activity in the system.

The management function relates to the total system with its basic objective being organization survival. The management function will not be discussed because it is assumed that the reader is familiar with the role of management in an organization. The management function is concerned with the organization, whereas the guidance function is concerned with the person in the system.

Activities Relating to the Model

The Department of Vocational and Technical Education should consider four sequential activities to increase the probability of achieving its objective of instruction which in its simplest term is to prepare individuals for gainful employment as skilled or semi-skilled workers. The four activities are recruiting, selecting, training, and placing.

The recruiting activity begins with the identification of the target population and terminates when the desired number of applicants has been obtained. During this period of time, it is necessary to inform the target population of the benefits of training and to generally acquaint them with the training program. It is also necessary to identify specific members of the population who may be eligible for training and motivate these people to apply for training. The selection activity begins with the screening of the applicants and ends when those found qualified are accepted for enrollment. The training activity begins at the start of the instructional program and terminates for a particular student when he successfully completes the course or drops out of the program. The placement activity begins when the individual graduates or begins seeking gainful employment in a job related to his training and terminates when he finds the job.

The first requirement of the recruiting activity is to make an analysis of the population which is to be served. This will entail initially separating the state population into two broad categories. One category will include those persons who have a special need for training and the other category will be formed from those remaining who do not qualify as special need persons. The special need category must then be sub-divided into the disadvantaged and handicapped groups. The disadvantaged group includes those persons who have academic, socio-economic, cultural, or other limitations that prevent them from succeeding in vocational education without specially designed educational programs or related services (1, p. 8). The handicapped group includes those persons who are health impaired and have a physiological deficiency such as deafness, blindness, crippled, mentally retarded, speech impaired, serious emotional disturbance, and others who cannot succeed in a training program without special educational assistance or require a modified vocational education program (1, p. 9).

Historically, the determination of the segment of the population chosen to be served was made by utilizing socio-political factors. The Vocational Education Amendments of 1968 in an attempt to assure that some portion of the disadvantaged and handicapped groups will be enrolled in training programs requires that the federal funds appropriated to a state must be apportioned in such a manner so that at least 15 per cent of the money will be used to train the disadvantaged and 10 percent of the funds will be used to train the handicapped (1, pp. 10-11).

The establishment of an effective communication system must be considered after the target population has been identified. The communication system is necessary because information must be disseminated to the members of the target population to inform them of the objectives of the training program and the benefits they can derive from such training, also the individual members of the target population must be persuaded or motivated to apply for enrollment into a training curriculum.

The need for establishing a communication system is even greater when the population to be served are the special needs persons which include the disadvantaged and handicapped groups. It is usually more time consuming, difficult and costly to identify, inform and motivate this population segment. Robert McKersie, an Associate Professor of Industrial Relations at the University of Chicago, discussed the problem of finding and recruiting qualified Negroes for the employment sector of today's society (33, p. 110). He reported that many companies do not have Negroes working for them simply because Negroes have not applied for employment. You have to advertise in the Negro newspapers; you have to put the word out to the community. The problem of finding qualified applicants is a difficult one.

Eli Ginzberg (34) discussed the problem of developing disadvantaged potential and emphasized the need for actively recruiting and motivating the disadvantaged Negro. Ginzberg states:

> The Negro must alter many of his values before he will be able to cope effectively with his new situation. To appraise how Negro potential can be fully developed therefore requires consideration of a whole complex of factors, ... to speed the development of Negro potential, therefore

> requires a concerted and simultaneous attack on all conditions that now impede that development (34, p. 236).

These two authors considered only the Negro group of the disadvantaged segment; however, the same difficulties can be inferred as being applicable to the other culturally disadvantaged groups. Special efforts and more resources will be required when attempting to motivate the disadvantaged and handicapped segments of the population to apply for vocational training. The degree to which the recruiting activity succeeds is largely dependent upon the capabilities of the administrators who are responsible for performing the guidance function. The output desired from the recruiting activity is an adequate number of applicants for training.

Evaluative instruments, criteria, and procedures to be used in the selection activity are now required. These criteria and selection procedures should be designed in a manner such that a comparison of student attributes and training course requirements can be properly made. This is done to increase the probability that the applicants selected will successfully complete the training program.

During the screening phase, it may be found that the attributes possessed by the applicants do not favorably match the existing curricula requirements thereby reducing the probability for a high graduation or completion rate. If this occurs and an irrevocable decision has been made that these applicants must receive training, then new training programs should be formulated such that the selected applicants will still have a high degree of probability for successfully completing the training program. New training programs can be started for many different reasons; however, careful matching of applicant characteristics with training curricula requirements is necessary for controlling the number of dropouts.

Applicants selected for enrollment in full-time public vocational training in the State of Oklahoma enter one of three instructional categories which are: secondary, post secondary, and adult. The secondary program includes full-time students in grades 9 through 12. The post secondary program is usually a two year program including grades 13 and 14. The adult program is of varying length for adults and those persons who are beyond the age of compulsory school attendance. The guidance function plays an important role in enrolling the proper applicant in the proper training program.

Training is the next activity to be completed in the manpower production system. The number of graduates available for placement in gainful employment is dependent upon the enrollment size and the number of students who do not drop out of the program. The number of enrollees who do not graduate (dropouts) is dependent upon many factors, the primary factors being the output quantity and quality of graduates desired, the procedures utilized during the selection process and the amount and type of training resources available. The dropout rate is an important parameter to continuously monitor. This rate can be effectively utilized as an indicator to determine when a review of the system should be conducted. A dropout rate in excess of some pre-determined value occurring at a designated point in time can bring attention to some undesirable occurrence taking place in the training system and act as a signal to institute a search for causal factors in one or more of the activities. Figure 3 shows the flow of persons through the vocational and technical education system.

The placement of trained graduates in gainful employment related to their training is not the direct responsibility of the Department of Vocational and Technical Education. However, if vocational and technical administrators are to effectively comply with the requirement for providing training which will allow the graduate to acquire gainful employment in a job related to training, then information regarding the employment sector needs and requirements is necessary for deciding what training courses should be expanded, reduced, abolished, or newly incepted. A strong implication is that one cannot effectively train individuals with skills for gainful employment if it is not first known what type of gainful employment opportunity exists or is forecast to exist. The newly designed Oklahoma occupational training information system (OTIS) which is in the developmental stage recognized this deficiency and is actively attempting to assess the trained manpower demand and supply of the employment sector. This type of data will

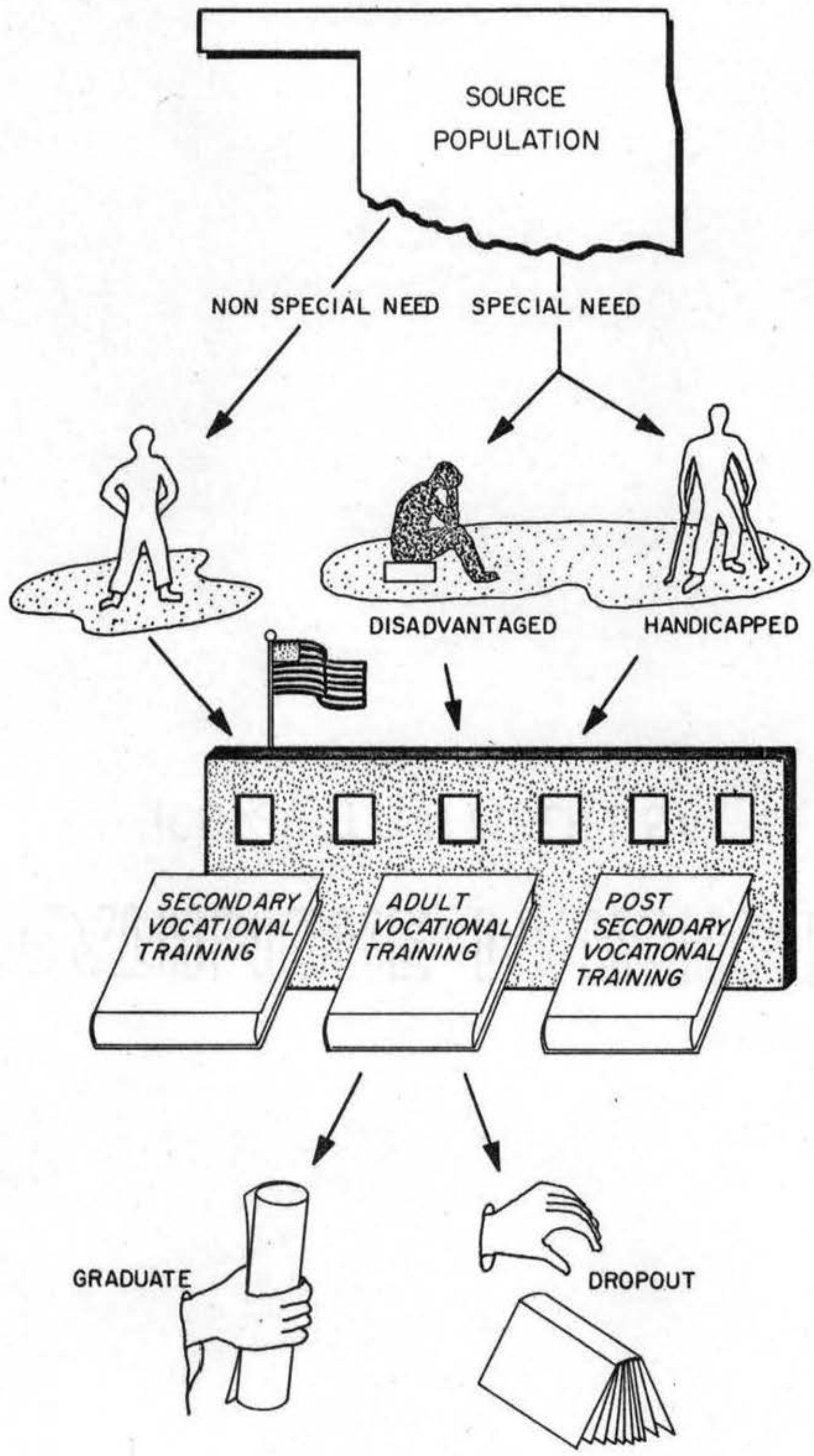

Figure 3. Flow of Persons Through the Vocational and Technical Education System

be very beneficial in aiding the vocational and technical education decision makers to more effectively alter their program training mix.

At present there is a serious void in making known to the vocational trained graduate the employment opportunities available in the State of Oklahoma. This has often resulted in the outmigration of skilled people who did not desire to leave the state but were compelled to do so for the sake of acquiring a job related to their training. Other results have been the acceptance of employment by the graduates in jobs not related to their training, and there are occurrences of some graduates completely withdrawing from the labor force (2). The Employment Security Commission is the public agency responsible for the placement of applicants who register for employment; however, it is sometimes not an effective effort. In many cases the initiative rests with the potential registrant before any action is taken to place a trained person in a related job and this often proves to be an inefficient process.

The alternatives available to the newly skilled graduate are primarily dependent upon the economic development of the state or, more specifically, the job opportunity available in the employment sector. When the job demands for a specific labor market skill are high and it is known where this demand exists, then the probability of obtaining a job related to training is increased. When the demand is low or unknown, the probability of securing work related to training is greatly reduced. The trained person who desires to remain in Oklahoma and work in a job related to training cannot fulfill his desire when no known demand for his skill exists. His alternative decision then may be to outmigrate, remain unemployed, continue education, withdraw from the labor force, take a part-time job, or accept full-time employment in a job not related to his training.

The personal needs, desires, and attitudes of the graduate, combined with his perception of the employment opportunity available in Oklahoma greatly affects the supply of trained manpower available to meet the employment demand required for economic development of the State. The degree to which the supply and demand for trained manpower is matched will directly affect the degree of economic development which can be achieved.

The vocational and technical education administrators have little or no control of the occupational demand requirement. This demand is usually dependent upon the degree of industrial development which exists within the State and its rate of change (growth or decline). However, the supply of trained manpower can be directly affected and controlled by the administrators of the vocational and technical education system.

The objective of vocational education to effectively train personnel for gainful employment is complexed by the fact that other sources are supplying skilled manpower to the total statewide trained human resources supply area.

Since the vocational and technical education system is not the sole source of skilled personnel used for meeting the demand for trained manpower, it is necessary to determine the percentage contribution to the total statewide supply for which it is responsible (its share of the market).

Variables Relating to the Model

The first task in any statewide manpower planning system is to acquire accountability data and information which will assist state level vocational planners assess the conditions of the employment environment of the State. The two interrelated variables needed to accomplish this task are the total statewide manpower demand and the total statewide manpower supply. The total statewide manpower demand is the total number of measured or projected job vacancies which exist during the period of time under consideration, categorized according to specific skill or "skill cluster" and the vacancy location in the state. The total statewide manpower supply is the total number of measured or projected skilled persons available during the time period under consideration, categorized according to specific skill, or "skill cluster" and the state supply source where this skilled person is located. Demand implies a need for a specific skill in a known location in the state. Supply implies a need satisfier with a specific skill from a known source in the state. The interfacing of demand and supply will determine the net manpower requirements for the state.

The determination of demand and supply data is not a relatively easy task. However, the complexity of this task should not dissuade those responsible for decision making in the vocational and technical education system from making every possible effort to acquire as much factual and reliable data as is economically feasible. American profit making industries which manufacture a product for use in the consumer market have coped with this problem quite successfully over the past years. Product demand, market share to supply, unit cost, optimum lot size to manufacture, and so forth are rarely completely known; however, manufacturing firms have developed procedures to acquire this data which allow them to survive in a highly competitive, everchanging environment. Many proven and accepted methods currently being used by these industries may have direct application for use by vocational and technical administrators and could be adopted with relatively few or no modifications required. The important point is that factual knowledge and data should be used to the fullest possible extent and judgment reserved for the components or conditions where factual information is absent (35, p. 190).

The complexity of acquiring demand and supply data in the manpower production area has been a constant concern of many experts. The methodology for making quantitative projections of supply-demand relationships were found to be rather primitive (27, p. 190). As a consequence, many attempts to make employment projections for future periods of five years or more have ended up rather far from the target. In an Employment Service Review article, Dr. Dael Wolfle, Executive Officer of the American Association for the Advancement of Science and publisher of Science, identified two methods of forecasting employment demands that had been used for some time:

1. The statistical projection of past and present information, adjusted by whatever assumptions were thought to be reasonable to establish a trend for the future.
2. Asking employers how many employees in certain occupational classifications they expected to have on their payrolls at some future date and adding up their replies (27, p. 190).

Although efforts have been made to refine both methods, neither one is wholly satisfactory.

Dr. Wolfle cited several factors that are important in determining the demand:

> *Certainly first to consider are the numbers of positions, or the requirements for stated kinds of services.
>
> *The way in which work in a field is organized. This is especially important in fields of work such as the health and technician occupations.
>
> *In many fields, the supply available helps to determine the demand. If we have plenty of technicians, we find ways to use technicians.
>
> *An increase in knowledge and skill in a field often brings about an increased demand for the services offered by professionals in that field.
>
> *Significant new knowledge in a field is likely

to lead to a marked increase in the demand for persons with that knowledge.

*Major, social, or political decisions that suddenly increase the demand for professionals of a given category. An example of this would be the advent of Medicare and Medicaid under Social Security which created a sharp increase in the demand for all kinds of trained workers in the health field.

Dr. Wolfle drew the following conclusions on the interacting supply and demand variables:

Some of the decisions that determine supply and demand are made by individuals where they make educational or vocational choices or when they decide to accept or reject a new job. Other decisions are made as deliberate acts of national policy. Still others come as consequences of a new development or an increase in knowledge.

To combine the multiple factors that determine supply and demand into an effective analytical model will surely require us to go far beyond the tallying of employers' estimates and the statistical projection of trends.

In addition to efforts to develop a manpower model that will necessarily be complex and difficult, other studies will be needed to provide the additional data the model will require.

Manpower trends should be examined from the economic point of view, for surely economic factors are involved. They also need to be examined from the psychological or sociological point of view, for certainly psychological and social factors are involved. Economists, sociologists, and psychologists have all studied manpower trends and problems, but most of their studies have been conducted from the point of view of a single discipline. When each works alone, important aspects are overlooked. They will continue to be until economists, psychologists, and sociologists learn each other's languages and learn how to work together.

The foregoing opinion describes the complexity of supply-demand relationships in making manpower projections.

Some states have recently attempted to determine the demand and supply components for their respective states. The Commonwealth of Pennsylvania utilized the statistical approach in early 1969 for establishing manpower trend data for the future (27). The State of Oklahoma used the direct survey approach which was to ask employers to state their future needs (2). This typifies the lack of agreement among the experts relevant to which of the two available methods for manpower data acquisition is the better. However, there is agreement that determination of demand and supply data is a necessary requirement for rendering valid decisions for changing the enrollment program mix of the vocational and technical education system. The methodology devised to this period of time is still primitive; however, the fact that positive efforts are being made to acquire demand and supply data on a longitudinal basis, then, with experience, the methodology should improve and the data should become more reliable and result in better decisions.

There are three alternatives available to the directors of training agencies who produce trained, skilled manpower for the total statewide manpower supply needed to meet the demand of the statewide employment sector. They are:

1. Train their required share of persons for the supply to equal the demand required (Supply = Demand).
2. Train a lesser share of persons than is required by demand (Supply < Demand).
3. Train a greater share of persons than is

required by demand (Supply > Demand).

Economic, political, and social conditions existing during the time period when a decision must be made will largely influence the alternative which will be chosen.

The target population size refers to the number of people in the population chosen to be served. The determination of the absolute size of this variable is usually not required. The only requirement is to assure that this population size is large enough to consider it an infinite source of potential enrollees for the vocational and technical education system or any other training system which will be used.

Of the total number of persons who successfully complete a training program, some are not available for satisfying the demand requirements of the state. Many outmigrate, continue their education, or withdraw. These constitute a loss of trained manpower not available for immediate gainful employment in the state and will be defined as defectors. This term is analogous to a completed production unit in a manufacturing system found to be defective during the inspection process, therefore not available for meeting consumer demand. The number of defectors must be subtracted from the graduate output to determine the number of skilled persons available for demand. Some states have established an extensive vocational student follow-up system to determine the mobility patterns of its graduates (37), (2).

Analysis of the manpower and occupational research environments indicate that the technology and methodology required for the quantitative determination of total demand, total supply, target population, and number of defectors are available. With more experience, improvements will be made for providing more reliable and valid assessments of the absolute values of these variables. The quantification of these variables will allow the use of mathematical models to enhance the probability of better decisions being made in the future.

The manpower production cycle begins and ends with the demand for certain types of skills by the labor markets. The interfacing or comparing of the statewide demand and supply variables will determine the net manpower requirement of the state and provide a basis for adjusting the outputs of the training systems under consideration. The net manpower requirement will be such that supply is greater than, equal to, or less than the demand. The total statewide adjustment based upon the net manpower requirement desired is then apportioned among the various manpower production sources in the state, thereby assessing the responsibility for each system to make a percentage change in their output quantity of trained persons. This will be defined as the adjustment share of the specific manpower production source.

Knowing the adjustment share, it is then possible to project the number of graduates required of each system making allowances for a loss of graduates, who for various reasons, will not be available for satisfying demand. With the required graduate output determined, the required number of enrollees can then be computed. Assuming that all enrollees during the training phase will not emerge as graduates due to some dropping out, the enrollment can be fixed by compensating for the projected number who are not expected to complete the training. The enrollees will be selected from the applicants who are deemed qualified for training. The applicants will be recruited from the target population in the state.

The need for a systematic collection of information was not considered essential in the past when most public manpower production systems were operating independently and usually accepting applicants on a first come, first served basis for any type of training available in the system to the extent that physical facilities and available monetary resources would allow. However, the present trend toward statewide manpower planning and the desire for economic growth require the joint cooperation of all the agencies producing trained people. Oklahoma has recognized the value of statewide manpower planning and has formed an advisory committee represented by members from the major manpower agencies of the state (2). The advisory committee members are listed in Appendix B.

Figure 4 describes the total manpower production cycle and shows that the variables are related and a change in any single variable value affects a value change in one or more

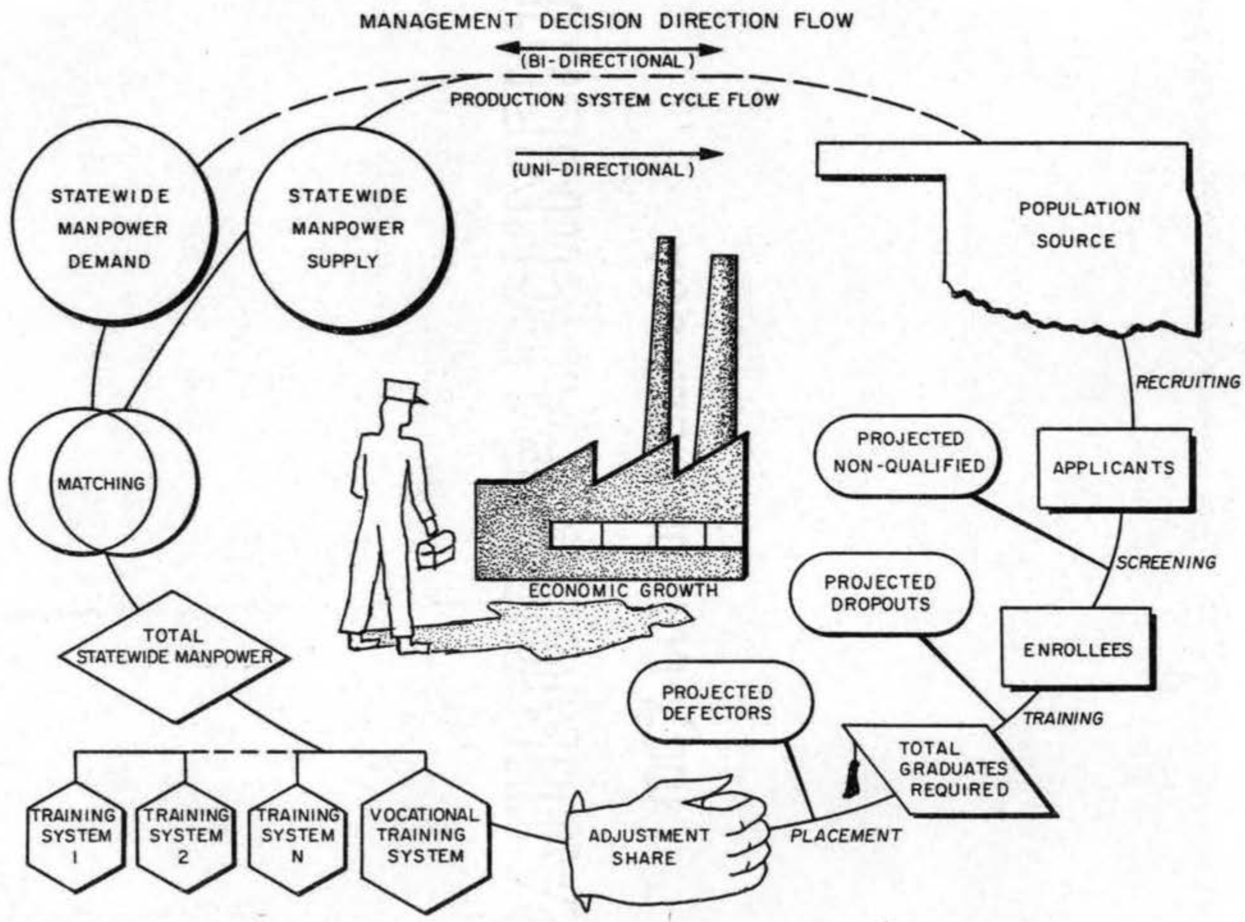

Figure 4. Total Manpower Production Cycle

of the remaining variables.

Methods for Determining Variable Data

The statewide net manpower requirement is derived from the interfacing between the forecast demand and supply. A decision process is then used for allocating percentages of the statewide adjustment to the various sources of manpower supply agencies. The allocated adjustment share will become each supply system output quantity objective. The decision process required for making this allocation is recognized by the author as being complex; however, the committee representing all the major supply agencies in the State of Oklahoma are actively attempting to develop policies which will be mutually acceptable to all of the participating agencies. The degree of agreement which can be achieved among these representatives will affect the demand-supply match or mis-match which occurs in the future. The use of past trend data, knowledge of individual system capabilities and resources, and other information can be used to quantitatively determine share of supply for each manpower production system.

The number of graduates can be easily and accurately determined. This will be the sum of all the persons who satisfactorily completed the specific training programs.

The number of defectors can be determined from data presently being collected by research coordinating units which now exist in the majority of states. Follow-up data being collected on a longitudinal basis should improve the accuracy of this data.

The projected number of dropouts can be easily determined from trend data acquired over the years. The enrollment minus the number of graduates will determine the number of dropouts. Projected enrollment size can be calculated by knowing the number of graduates required and the projected number of dropouts. The sum of these two variables will be the enrollment value.

A detailed quantitative assessment of the number of applicants, qualified or not qualified for enrollment, and the population size is rarely required. There is evidence to indicate that this can be considered an infinite source since re-training, birth rate, industrial expansion and change, and other factors are continuously adding to the population of people who express a need for training (38).

Training Cycle

The manpower production cycle for the vocational and technical education system goes through a number of processes and finally returns to its initial state. The scientific interpretation of a cycle as accepted by thermodynamicists is also applicable to the vocational education system. This is viewed as a system in some existing or given state condition which goes through a number of different processes then finally returns to its initial state. It is then considered to have undergone a cycle (39, p. 18). Therefore, at the conclusion of the cycle, all the properties have the same value they had at the beginning. The following illustrates how this is analogous to a training system. The state of the training system is such that a training need condition exists. A particular particle, in this case a human being in the population, undergoes a number of processes through the system activities and returns to the population origin. The original property of this person was the need for training. Upon returning to the population, the same need for training will still exist. This training, re-training cycle need exists for the life of the particle. The value of training can be viewed as being constant in that it is perceived to aid in the betterment of the individual. The cyclic effect of training might possibly be one explanation for assuming the population source to be of infinite size.

The manpower production cycle for economic growth has four basic processes. These are recruiting, selecting, training, and placement. The recruiting process transforms a segment of the population into applicants. The selection process converts the applicants into enrollees. The training process changes the enrollees into skilled graduates. The placement process creates a gainful employee who will contribute to the economic growth of the state.

Management Decision Directions of Flow

The manpower development cycle can be assumed to be in a static phase of equilibrium until a management decision is made to change a particular state path of the cycle. The management decision direction flow is considered to be bi-directional; that is, it can begin at any state in the system and flow in a clockwise or counter-clockwise direction (see Figure 4). The historic management direction flow for the vocational and technical education system has been clockwise with the origin usually at the applicant state. This infers that the number of enrollees accepted would depend upon the resources and capabilities of the system and the number of applicants available. The enrollees enter training with some successfully graduating and others dropping out. The number of graduates who find work in occupations related to their training would depend upon the type of skill which they acquired, the employment sector demand for this skill and the placement services available. <u>This approach forces</u> the acceptance of whatever economic growth results. The clockwise management direction of flow has often resulted in the training of personnel with skills for which no employment demand exists. Opportunity for gainful employment is often reduced and re-training of the graduate may be required. This clockwise management decision direction flow is unfair to the individual seeking to better his position in life and to the state which invests in the training hoping to achieve economic growth.

The counter-clockwise management decision direction flow appears to be the more desirable of the bi-directional flows. This begins with an assessment of the economic opportunity available in the employment environment. The matching of manpower demand and supply variables provides a basis for the many training systems present in a state or region to determine the percentage of manpower supply they should be training in a specific skill curriculum. From data such as this, the vocational and technical education system managers can determine their manpower graduate output desired and reduce the duplication of skills generated by the other training systems. Projections could then be made regarding the number of enrollees and applicants needed after allowing for dropouts and non-qualified applicants. Decisions could be simultaneously made regarding necessary changes in enrollment mix relevant to training of the skills for which there is a known demand. It has been previously shown that the employment sector is dynamic and skill demands are ever changing. This implies that if gainful employment for the skilled graduate is the objective of a training system, then the training system must respond by change. The stated objective of vocational and technical education is to provide a person with a skill necessary for gainful employment; therefore, it too must change. The counter-clockwise management flow appears to be the better choice for making effective decisions.

Skill Development Direction Flow

The development of skilled manpower begins with an individual from some target population who is recruited as a training applicant. The selection activity determines those applicants who will be enrolled in training for the acquisition of a skill. The skilled graduate hopefully will be placed in a job related to his training, thereby satisfying his subjective needs and contributing to the economic growth of the state. This direction flow is always uni-directional and clockwise.

CHAPTER III

DEVELOPMENT OF EQUATIONS RELATED TO THE MODEL

Review

The previous chapter discussed the model variables in a general manner to acquaint the reader with the considerations used for developing the expressions relating to the model. Briefly summarizing, the total statewide manpower demand and total statewide manpower supply must be properly interfaced in order to achieve the maximum return in industrial growth of the economy. One should remember that the total statewide manpower demand refers to the total labor market need for specific skills whereas the total statewide manpower supply refers to the total number of skilled people available in the labor force. The interfacing or comparison of these two variables indicates the net manpower requirement of the state for the specific skills considered. This interfacing will indicate the degree in which all the various manpower training systems are realistically attuned to the needs of the state's employment sector. It will also indicate the type of skills which are over or under-supplied and indicate an adjustment to be made in the enrollment mixes of the various training agencies. The net manpower requirement and adjustment required will be considered as being synonymous in the context of this study.

In any discussion or planning of a system relating to manpower training or human resource development, the prime element for consideration must be the individual person. This study recognizes the human needs, aspirations, emotions, and desires of the persons in the training system by placing the guidance function on the same hierarchal level as the management function. Like the management function's concern for organizational survival, the guidance function is concerned with the survival of the individual in an environment conducive to fulfilling his aspirations and goals. In the remainder of this study, the manpower considerations will pertain only to skill requirements. The person will be the medium by which a skill development supply source can transport its skill output to some location which has a demand for this skill in gainful employment. The dehumanization of the person is not intended. For the sake of clarity in the development of expressions relating to the model, the skill characteristic of the person is the dimensional unit used.

Demand

The demand variable refers to a specific skill requirement of a vacant job in a certain employment location. The total statewide demand may be referred to as demand and defined as the total number of a specific skill or "skill cluster" required by all the various organizations located in the state which hire persons for gainful employment. Demand is usually generated by the need to replace persons who vacate a job and by the creation of new jobs. The symbol D will be used to identify the total statewide demand for all skills.

Let: D be the total statewide demand for all skills.

D_j be the total statewide demand for the j^{th} skill.

d_{ij} be the demand of the i^{th} location in the state for the j^{th} skill.

i be the demand location in the state.

j be the specific skill required.

m be the number of specific skills required.

n be the number of demand locations in the state.

In summation form, the total statewide demand for all skills may be written as:

$$D = \sum_{j=1}^{j=m} D_j \qquad (1)$$

where the total statewide demand for all skills is obtained by summing all the total statewide demands D_j over all the m skills.

The total statewide demand for the j^{th} skill may be written as:

$$D_j = \sum_{i=1}^{i=n} d_{ij} \qquad (2a)$$

or

$$D_j = d_{\cdot j} \qquad (2b)$$

where the total statewide demand for the j^{th} skill is obtained by summing over all the d_{ij} demands for the particular skill over all the n demand locations in the state.

Supply

The supply variable refers to a specific skill which a person must possess to fill a vacant job in a certain employment location. The total statewide supply will be referred to as supply and defined as the total number of a specific skill or "skill cluster" produced by the various training systems located in the state. Supply is affected by the number, type and size of training systems in the state, the migration pattern in and out of the state, the human characteristics of the persons selected for training, the resources available for training and other factors. The symbol S will be used to identify the total statewide supply for all skills.

Let: S be the total statewide supply for all skills.

S_j be the total statewide supply for the j^{th} skill.

S_{kj} be the supply of the k^{th} source in the state for the j^{th} skill.

j be the specific skill produced.

k be the supply source location in state.

p be the number of specific skills produced.

r be the number of supply source locations in the state.

In summation form, the total statewide supply for all skills may be written as:

$$S = \sum_{j=1}^{j=p} S_j \tag{3}$$

where the total statewide supply for all skills is obtained by summing all the total statewide supplies S_j over all the p skills.

The total statewide supply for the j^{th} skill may be written as:

$$S_j = \sum_{k=1}^{k=r} s_{kj} \tag{4a}$$

or

$$S_j = s_{.j} \tag{4b}$$

where the total statewide supply for the j^{th} skill is the summation over all the k^{th} supply source locations in the state.

Adjustment

The degree of match which exists between demand and supply may significantly affect the economic growth of the state and the alternative course of action taken by a trained individual. The differential between demand and supply is the net manpower required. This differential will indicate the adjustment needed to meet the demand of the labor market of the state. This variable will be referred to as adjustment and identified by the symbol X.

The significant aspect of the adjustment variable is that it can serve as an indicator for assessing the total occupational environment of the state to ascertain if the training systems are realistically attuned to the needs of the employment sector. Public training systems have stated their objective as providing individuals with skills required for gainful employment. This demand minus supply variable can be used to evaluate the effectiveness of the public training systems in meeting their objective. A more important use for this variable is that its value indicates the type of training program changes which should be made in order to produce the skills for which there is the highest net demand.

The complex interrelationship between demand and supply was discussed in the previous chapter. The optimal differential between demand and supply to make the maximum contribution to economic growth is still unknown. It is recognized that an oversupply of skilled manpower existing in the state may be a factor in attracting new industry, thereby creating more demand and achieving a balance, or the oversupply of persons may increase outmigration which would also reduce the imbalance. An overdemand of skilled manpower may provide a stimulus for persons to in-migrate or force industries to operate at a lower level of production or even leave the state. Since the optimal degree of imbalance required for maximum economic growth is still unknown, this study will assume that the adjustment variable should take the value which would make the supply equal to the demand. If future research ascertains the percentage of difference between demand and supply which optimizes economic growth, then this percentage may be used by decision makers and the ensuing expressions will still be valid.

The value of the adjustment variable X can be any positive, negative, or zero integer. The comparison of demand and supply is illustrated in Figure 5.

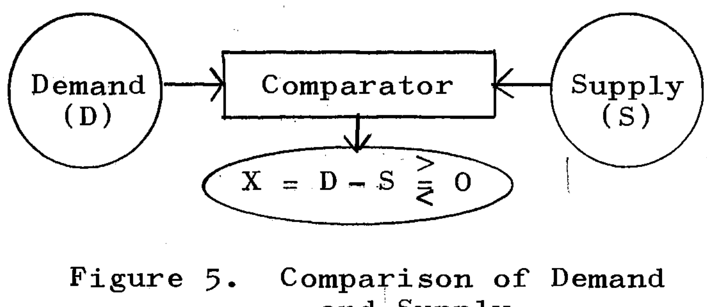

Figure 5. Comparison of Demand and Supply

The expression for determining the value of the adjustment variable can be written as:

$$\text{Total statewide manpower adjustment} = \text{Statewide manpower demand} - \text{Statewide manpower supply}$$

or

$$X = D - S \tag{5}$$

where: X is the total statewide adjustment.

D is the total statewide demand.

S is the total statewide supply.

Then, for any j^{th} skill, Equation 5 can be written as:

$$X_j = D_j - S_j \tag{6a}$$

substituting:

$$X_j = \sum_{i=1}^{i=n} d_{ij} - \sum_{k=1}^{k=r} s_{kj} \tag{6b}$$

or

$$X_j = d_{.j} - s_{.j} . \tag{6c}$$

The $(\cdot)$ symbolizes the need to sum over all the demand locations and supply organizations where the j^{th} skill exists,

where: X_j is the total statewide adjustment for the j^{th} skill.

$d_{.j}$ is the total statewide demand for the j^{th} skill.

$s_{.j}$ is the total statewide supply for the j^{th} skill.

Adjustment Share

To assure that the desired total statewide adjustment is achieved, it then becomes necessary to allocate responsibility for a certain percentage of the adjustment to all the individual supply sources of the specific skill. This percentage can be decided through an arbitrary decision process involving the directors of all the individual supply sources in the state. A committee composed of representatives from the major sources of supply presently exists in Oklahoma. One of their immediate objectives should be the determination of methods for allocating the percentage of adjustment for which each training system will assume the responsibility of providing. A simple method of allocating the percentage of adjustment to each individual supply source could be determined by calculating the share of total statewide supply the source is presently providing and pro-rate on this basis. The adjustment share allocated to each supply source in the state for the production of a certain skill will be identified by the symbol α_{kj}.

Then:

$$\alpha_{kj} = \frac{s_{kj}}{S_j} \tag{7a}$$

or

$$\alpha_{kj} = \frac{s_{kj}}{s_{\cdot j}} \tag{7b}$$

where: α_{kj} is the adjustment allocated to the k^{th} supply source location in the state for the j^{th} skill.

s_{kj} is the supply of the k^{th} source in the state for the j^{th} skill.

S_j is the total statewide supply for the j^{th} skill.

To determine the absolute value of the change in output supply of any k^{th} source location in the state for the j^{th} skill, multiply the total adjustment for the j^{th} skill (X_j) by the adjustment share fraction (α_{kj}).

Then:

$$x_{kj} = X_j(\alpha_{kj}) \qquad (8)$$

where: x_{kj} is the absolute value of the change in output supply from the k^{th} source location in the state for the j^{th} skill.

X_j is the total statewide adjustment for the j^{th} skill.

α_{kj} is the adjustment share of the k^{th} source location in the state for the j^{th} skill.

Figure 6 illustrates the segment of the manpower development cycle considered thus far.

Vocational and Technical Education System

The remainder of this chapter will relate to the vocational and technical system (vo-tech) as the k^{th} supply source location. The k subscript will be dropped since the system under consideration has been identified as vo-tech. Therefore,

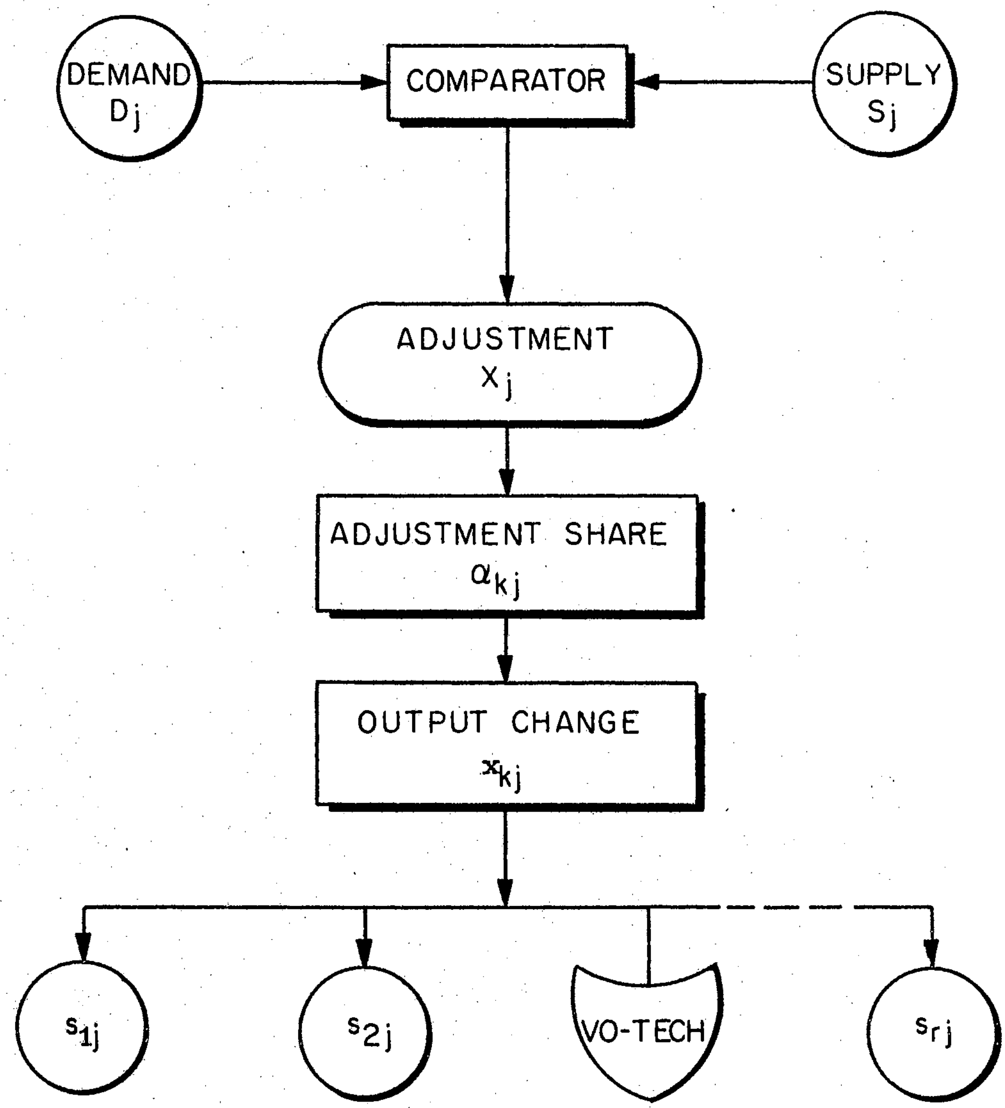

Figure 6. Manpower Development Cycle Segment Up to the Vocational and Technical Education System

α_{kj} can be written as α_j

and

x_{kj} can be written as x_j

where: k relates to the vo-tech system

j is the percentage change in output required from the vo-tech system for the j^{th} skill.

x_j is the incremental number of the j^{th} skill that vo-tech must supply as its share to the total statewide adjustment X_j.

The major variables of the vo-tech system for the j^{th} skill are shown in Figure 7.

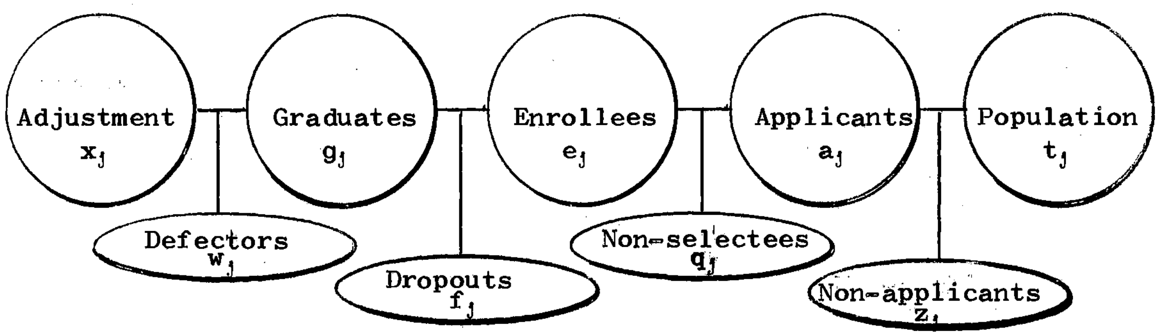

Figure 7. The Major Variables of the Vo-Tech System for the j^{th} Skill

Where: a_j is the number of applicants in the vo-tech system for the j^{th} skill.

e_j is the number of enrollees in the vo-tech system for the j^{th} skill.

f_j is the number of dropouts in the vo-tech sysem for the j^{th} skill.

g_j is the number of graduates from the vo-tech system for the j^{th} skill.

q_j is the number of non-selected applicants in the vo-tech system for the j^{th} skill.

t_j is the target population to be served by the vo-tech system for the j^{th} skill.

w_j is the number of defectors in the vo-tech system for the j^{th} skill.

x_j is number of j^{th} skill graduates that the vo-tech system must supply as its share to the total statewide adjustment.

z_j is the number of persons in the target population who do not apply for vo-tech training for the j^{th} skill.

Remembering that the total statewide adjustment X_j is the incremental change required to achieve the desired balance between demand and supply, then x_j is also an incremental output change relating to the k^{th} supply source, which in this case is vo-tech. The incremental number of j^{th} skill graduates that vo-tech must supply, (x_j) establishes the minimum number of graduates that must be produced. If there were no losses, which means that all graduates are avilable for satisfying the X_j variable requirement, then this would be the ideal case. For this case the change in graduate output required would be equal to the output change which vo-tech must supply. Then,

$$g_j = x_j \text{.} \tag{9}$$

As usually occurs in the real world, the ideal, perfect case rarely exists; with any activity, there is generally an associated loss. Not all graduates who are trained by the vocational and technical education system are available for placement in related jobs within the boundaries of the state. Many outmigrate to contiguous states or enter the armed forces, others continue in school to further their education, and some completely withdraw from the labor force and will not accept employment. This group of graduates is a loss and termed defectors and identified by the symbol w_j. Then,

the output of graduates needed = (incremental output allocated to the system) + (number of defectors)

$$g_j = x_j + w_j \tag{10}$$

where: g_j is the number of graduates from the vo-tech system for the j^{th} skill.

w_j is the number of defectors in the vo-tech system for the j^{th} skill.

The defection rate can be calculated by dividing the number of graduates who defect by the total graduate output. The defection rate will be identified by the symbol β_j.

Then,

$$\beta_j = \frac{w_j}{g_j} \qquad (11)$$

where: β_j is the rate of defection.

The training activity similar to the placement activity is not one hundred per cent efficient; it also incurs a loss. For the ideal case, all enrollees would emerge as graduates with a developed skill. The loss incurred during the training activity will be called dropouts. A dropout is defined as an enrollee who fails to complete the training program and departs without graduating. The dropouts will be identified by the symbol f_j. The number of enrollees required is the sum of the number of graduates required and the number of dropouts. Then,

$$e_j = g_j + f_j \qquad (12)$$

where: e_j is the number of enrollees required in the vo-tech system for the j^{th} skill.

g_j is the number of graduates required from the vo-tech system for the j^{th} skill.

f_j is the number of dropouts in the vo-tech system from the j^{th} skill.

The dropout rate can be calculated by dividing the number of dropouts by the original number of enrollees. The dropout rate will be identified by the symbol γ_j. Then,

$$\gamma_j = \frac{f_j}{e_j} \qquad (13)$$

where: γ_j is the dropout rate.

The graduation rate can be calculated by dividing the number of graduates by the original number of enrollees, or by subtracting the dropout rate from unity. The graduation rate will be identified by the symbol δ_j. Then,

$$\delta_j = \frac{g_j}{e_j} \tag{14a}$$

or

$$\delta_j = (1 - \gamma_j). \tag{14b}$$

The number of enrollees which are needed to supply the desired number of graduates will be obtained during the selection activity. Not all the applicants who express a need for training will be selected. The capabilities and resources available to the vo-tech system plus the characteristics of the applicants will be limiting factors affecting the number of applicants accepted for training. The minimum number of applicants required is determined by the number of graduates desired. The greater the number of applicants in relation to the number of enrollees required will afford the adoption of more rigid screening standards and allow for a greater degree of selectivity. This would increase the probability that the dropout rate would be decreased and the quality of graduate would be higher. However, it must be remembered that the vocational and technical education system has an obligation to serve all segments of the population and must attempt to train the disadvantaged and handicapped segments of this society. Therefore, the selection activity must weigh the needs of all who express a desire for occupational training and should not consider only graduation rate when screening applicants for enrollment status. The applicants who are not accepted for enrollment will be termed non-selectees and identified by the symbol q_j. The number of applicants required will be the sum of the number of enrollees needed and the number of non-selectees. Then,

$$a_j = e_j + q_j \tag{15}$$

where: a_j is the number of applicants required in the vo-tech system for the j^{th} skill.

e_j is the number of enrollees required in the vo-tech system for the j^{th} skill.

q_j is the number of non-selected applicants in the vo-tech system for the j^{th} skill.

The number of applicants expressing a need for vocational training is considered to be infinite in relation to the number of enrollees who are accepted into training. Therefore, as long as this condition exists, a quantitative determination of the applicant size is not required. If in the future some particular j^{th} training course does not comply with the infinite relationship, then the need for a quantitative assessment may arise.

The target population to be served is the last remaining variable in the vo-tech manpower production system.

This is the source of applicants for the training system. The target population is composed of persons who will or will not apply for occupational training. Similar to the applicant variable a_j, vocational and technical educators have provided evidence to indicate that the population size is infinite relative to the vo-tech training system. Therefore, as long as this relationship holds true, a quantitative determination of its size is also unnecessary. The target population will be identified by the symbol t_j and the non-applicants will be identified by the symbol z_j. The target population size will be the sum of the number of applicants and number of non-applicants. Then,

$$t_j = a_j + z_j \tag{16}$$

where: t_j is the target population to be served by the vo-tech system for the j^{th} skill.

a_j is the number of applicants in the vo-tech system for the j^{th} skill.

z_j is the number of non-applicants in the vo-tech system for the j^{th} skill.

Summary of Expressions

1. Demand

$$D = \sum_{j=1}^{j=m} D_j$$

$$D_j = \sum_{i=1}^{i=n} d_{ij} = d_{\cdot j}$$

2. Supply

$$S = \sum_{j=1}^{j=p} S_j$$

$$S_j = \sum_{k=1}^{k=r} s_{kj} = s_{\cdot j}$$

3. Adjustment

$$X = D - S$$

$$X_j = D_j - S_j$$

$$X_j = \sum_{i=1}^{i=n} d_{ij} - \sum_{k=1}^{k=r} s_{kj}$$

$$X_j = d_{\cdot j} - s_{\cdot j}$$

4. Adjustment share

$$\alpha_{kj} = \frac{s_{kj}}{S_j} = \frac{s_{kj}}{s_{\cdot j}}$$

$$x_{kj} = X_j (\alpha_{kj})$$

5. Graduates

$$g_{kj} = x_{kj} + w_{kj}$$

6. Defection rate

$$\beta_{kj} = \frac{w_{kj}}{g_{kj}}$$

7. Enrollees

$$e_{kj} = g_{kj} + f_{kj}$$

8. Graduation and Dropout rates

$$\delta_{kj} = \frac{g_{kj}}{e_{kj}}$$

$$\gamma_{kj} = \frac{f_{kj}}{e_{kj}}$$

$$\delta_{kj} + \gamma_{kj} = 1$$

9. Applicants

$$a_{kj} = e_{kj} + q_{kj}$$

10. Target Population

$$t_{kj} = a_{kj} + z_{kj}$$

11. Adjustment for <u>vo-tech as the kth</u> source of supply.

$$x_j = t_j - (z_j + q_j + f_j + w_j)$$

When the target population size is capable of providing an infinite number of applicants such that the desired number of enrollees can be acquired, then Equation (11) can be written as:

12. $$x_j = e_j - (f_j + w_j).$$

Symbols Defined

i is the demand location in the state.

j is the specific skill required.

k is the supply source location in the state.

m is the number of specific skills required.

n is the number of demand locations in the state.

p is the number of specific skills produced.

r is the number of supply source locations in the state.

D is the total statewide demand for all skills.

D_j is the total statewide demand for the j^{th} skill.

S is the total statewide supply for all skills.

S_j is the total statewide supply for the j^{th} skill.

X is the total statewide adjustment for all skills.

X_j is the total statewide adjustment for the j^{th} skill.

d_{ij} is the demand of the i^{th} location in the state for the j^{th} skill.

$d_{\cdot j}$ is the total statewide demand for the j^{th} skill.

s_{kj} is the supply of the k^{th} source location in the state for the j^{th} skill.

$s_{\cdot j}$ is the total statewide supply for the j^{th} skill.

a_{kj} is the number of applicants required by the k^{th} supply source in the state for the j^{th} skill.

e_{kj} is the number of enrollees required by the k^{th} supply source in the state for the j^{th} skill.

f_{kj} is the number of dropouts in the k^{th} supply source in the state for the j^{th} skill.

g_{kj} is the number of graduates required from the k^{th} supply source in the state for the j^{th} skill.

t_{kj} is the target population source of applicants for the k^{th} supply source in the state for the j^{th} skill.

w_{kj} is the number of defectors in the k^{th} supply source in the state for the j^{th} skill.

x_{kj} is the adjustment value of graduates required of the k^{th} supply source in the state for the j^{th} skill.

z_{kj} is the number of persons in the target population who do not apply to the k^{th} supply source in the state for training in the j^{th} skill.

β_{kj} is the defection rate of the k^{th} supply source in the state for the j^{th} skill.

γ_{kj} is the dropout rate of the k^{th} supply source in the state for the j^{th} skill.

δ_{kj} is the graduation rate in the k^{th} supply source in the state for the j^{th} skill.

Activity Cost Expression

A prime requirement for analyzing the vocational and technical education system is to identify the costs associated with the activities of the system. The total activity cost expression for the vocational and technical education system can be written as:

$$TAC = RC + SC + TC + PC$$

where: TAC is the total activity cost to produce a trained graduate from a target population and place the graduate in a position of gainful employment related to his training.

RC is the recruiting cost incurred to obtain an applicant from the target population.

SC is the screening cost incurred to obtain an enrollee from the available applicants.

TC is the training cost incurred to develop a skilled graduate from the enrollees.

PC is the placement cost to put a skilled graduate in a job related to his training.

Lead Time

When the demand for skills is to be supplied by the vocational and technical education system, the variable of time must be considered. The time required for the completion of each activity must be determined so as to assure that the supply for a certain skill will be available during the period of the forecast demand. The total lead time required will then be the sum of the four activity times required for the development of the specific skill. The lead time expression for the vocational and technical education system can be written as

$$TLT = RT + ST + TT + PT$$

where: TLT is the total lead time required to produce a trained graduate from a target population and place the graduate in a position of gainful employment related to his training.

RT is the time required to recruit an applicant from the target population.

ST is the time required to select the applicant for enrollment status.

TT is the time required to train an enrollee as a skilled graduate.

PT is the time required to place a skilled graduate in a job related to his training.

CHAPTER IV

PRACTICAL APPLICATIONS OF THE MODEL FOR THE VOCATIONAL AND TECHNICAL EDUCATION SYSTEM

The mathematical expressions previously developed can be a powerful, easily applied and useful tool for the managers of the vocational and technical education system. It is simply a manpower accounting procedure. The total statewide manpower planning which included all the supply sources in the state was discussed in Chapter III. It will be demonstrated in this chapter how the vocational and technical education system can apply the industrial engineering techniques of linear programming to determine the optimal enrollment mix, and a statistical quality control technique to control the enrollment mix model. These techniques will greatly aid the vo-tech manager in effectively satisfying his adjustment share $\sum_{j=1}^{j=7} x_{kj}$.

Recall that in the statewide employment sector there exists a total demand D_j for a particular j^{th} skill in all n locations. The supply S_j of the j^{th} skill is derived from all the r sources. By interfacing and comparing the statewide demand and total statewide supply, the total statewide adjustment X_j for the j^{th} skill can be determined. It was shown that the adjustment share for any k^{th} supply source to satisfy the statewide adjustment for all the skills would be $x_{k1}, x_{k2}, \ldots, x_{kj}$. Identifying the k^{th} supply source as vo-tech, then x_{kj} is vo-tech's share to meet the required statewide adjustment X_j; and redefines $x_{kj} = x_j$.

The number of enrollees e_j required by vo-tech will be the adjustment share x_j readjusted for defectors and drop-outs. Then

$$e_j = x_j + w_j + f_j .$$

Let the optimal enrollment for the j^{th} skill be identified by Y_j where

(a) $Y_j \leq e_j$ if there are any budget constraints.

(b) $Y_j = e_j$ for all cases if there are no budget constraints.

In the case where there is a budget constraint, $Y_j \leq e_j$, the linear program technique will be used to find the optimal enrollment mix for the corresponding enrollment mix inequality constraints and the budget constraint.

Linear Programming Problem

In order to meet the total statewide adjustment $\sum_{j=1}^{j=7} X_j$ for the seven skills, the vo-tech system must have $\sum_{j=1}^{j=7} y_j$ enrollees for the seven skills to provide its adjustment share. The total entry level salary is represented by $Z = \sum_{j=1}^{j=7} p_j y_j$. Because of the enrollment mix and budget inequality constraints, the problem becomes one of optimizing

$Z = \sum_{j=1}^{j=7} p_j y_j$ subject to the given constraints. The optimizing of $Z = \sum_{j=1}^{j=7} p_j y_j$ means that the objective is to give priority for training to those skills which will contribute most to the generation of entry level salary for consumer spending in the state. Therefore,

maximize

$$Z = \sum_{j=1}^{j=7} p_j y_j$$

subject to

(1) $0 \leq y_j \leq e_j$ for all $j = 1, \ldots, 7$.

(2) $\sum_{j=1}^{j=7} c_j y_j \leq B$

where

p_j is the entry level salary for the j^{th} skill

c_j is the total instructional cost for producing the j^{th} skill

B is the instructional budget allocated to the vo-tech system

e_j is the enrollment of the j^{th} skill required.

y_j is the enrollment of the j^{th} skill produced from the model.

Z is the total entry level salary generated.

Rewriting the expression gives

maximize

$$Z = p_1 y_1 + p_2 y_2 + p_3 y_3 + p_4 y_4 + p_5 y_5 + p_6 y_6 + p_7 y_7$$

subject to

(1) $c_1y_1 + c_2y_2 + c_3y_3 + c_4y_4 + c_5y_5 + c_6y_6 + c_7y_7 \leq B$

(2) $y_1 \leq e_1$

(3) $y_2 \leq e_2$

(4) $y_3 \leq e_3$

(5) $y_4 \leq e_4$

(6) $y_5 \leq e_5$

(7) $y_6 \leq e_6$

(8) $y_7 \leq e_7$

where

p_1 = 3687 dollars	c_1 = 143 dollars	e_1 = 558 enrollees
p_2 = 3222 dollars	c_2 = 158 dollars	e_2 = 1809 enrollees
p_3 = 4214 dollars	c_3 = 221 dollars	e_3 = 442 enrollees
p_4 = 3000 dollars	c_4 = 153 dollars	e_4 = 149 enrollees
p_5 = 3785 dollars	c_5 = 217 dollars	e_5 = 1209 enrollees
p_6 = 5667 dollars	d_6 = 360 dollars	e_6 = 1050 enrollees
p_7 = 3754 dollars	c_7 = 225 dollars	e_7 = 5122 enrollees

B = 1,500,000 dollars.

Adding slack u_m to formulate equality constraints and substituting in the values for p_j, e_j, and c_j gives

maximize

$$Z = 3687y_1 + 3222y_2 + 4214y_3 + 3000y_4 + 3785y_5 + 5667y_6 + 3754y_7$$

subject to

(1) $143y_1 + 158y_2 + 221y_3 + 153y_4 + 217y_5 + 360y_6 + 225y_7 + u_8 = 1,500,000$

(2) $y_1 + u_1 = 558$

(3) $y_2 + u_2 = 1809$

(4) $y_3 + u_3 = 442$

(5) $y_4 + u_4 = 149$

(6) $y_5 + u_5 = 1209$

(7) $y_6 + u_6 = 1050$

(8) $y_7 + u_7 = 5122$

The slack variable u_m indicates the unused portion of enrollees which remain after the optimal solution has been attained. These equations will be used to form the initial tableau for iteration to find the optimal solution.

Initial Tableau

Coefficients of Solution Variables (p_j)	z_j Solution Variables	p_1 y_1	p_2 y_2	p_3 y_3	p_4 y_4	p_5 y_5	p_6 y_6	p_7 y_7	0 u_1	0 u_2	0 u_3	0 u_4	0 u_5	0 u_6	0 u_7	0 u_8	e_j
0	u_1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	e_1
0	u_2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	e_2
0	u_3	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	e_3
0	u_4	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	e_4
0	u_5	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	e_5
0	u_6	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	e_6
0	u_7	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	e_7
0	u_8	C_1	C_2	C_3	C_4	C_5	C_6	C_7	0	0	0	0	0	0	0	1	B
$z_j(p_j)$		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
$z_j - z_j(p_j)$		p_1	p_2	p_3	p_4	p_5	p_6	p_7	0	0	0	0	0	0	0	0	

Tableau 2

		3687	3222	4214	3000	3785	5667	3754	0	0	0	0	0	0	0	0	
		y_1	y_2	y_3	y_4	y_5	y_6	y_7	u_1	u_2	u_3	u_4	u_5	u_6	u_7	u_8	e_j
0	u_1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	558
0	u_2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1,809
0	u_3	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	442
0	u_4	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	149
0	u_5	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1,209
0	u_6	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1,050
0	u_7	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	5,122
0	u_8	143	158	221	153	217	360	225	0	0	0	0	0	0	0	1	1,500,000
		3687	3222	4214	3000	3785	5667	3754	0	0	0	0	0	0	0	0	0

Tableau 3

Coefficients of Solution Variables (p_j)	z_j Solution Variables	p_1 y_1	p_2 y_2	p_3 y_3	p_4 y_4	p_5 y_5	p_6 y_6	p_7 y_7	0 u_1	0 u_2	0 u_3	0 u_4	0 u_5	0 u_6	0 u_7	0 u_8	e_j
0	u_1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	558
0	u_2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1,809
0	u_3	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	442
0	u_4	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	149
0	u_5	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1,209
5667	y_6	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1,050
0	u_7	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	5,122
0	u_8	143	158	221	153	217	0	225	0	0	0	0	0	-360	0	1	1,122,000
		3687	3222	4214	3000	3785	0	3754	0	0	0	0	0	-5667	0	0	-5,950,350

Tableau 4

		y_1	y_2	y_3	y_4	y_5	y_6	y_7	u_1	u_2	u_3	u_4	u_5	u_6	u_7	u_8	e_j
0	u_1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	558
0	u_2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1,809
4214	y_3	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	442
0	u_4	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	149
0	u_5	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1,209
5667	y_6	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1,050
0	u_7	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	5,122
0	u_8	143	158	0	153	217	0	225	0	0	-221	0	0	-360	0	1	1,024,318
		3687	3222	0	3000	3785	0	3754	0	0	-4214	0	0	-5667	0	0	-7,812,938

Tableau 5

Coefficients of Solution Variables (p_j)	z_j Solution Variables	p_1 y_1	p_2 y_2	p_3 y_3	p_4 y_4	p_5 y_5	p_6 y_6	p_7 y_7	0 u_1	0 u_2	0 u_3	0 u_4	0 u_5	0 u_6	0 u_7	0 u_8	e_j
0	u_1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	558
0	u_2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1,809
4214	y_3	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	442
0	u_4	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	149
3785	y_5	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1,209
5667	y_6	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1,050
0	u_7	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	5,122
0	u_8	143	158	0	153	0	0	225	0	0	-221	0	-217	-360	0	1	762,065
		3687	3222	0	3000	0	0	3754	0	0	-4214	0	-3785	-5667	0	0	-12,389,003

Tableau 6

		y_1	y_2	y_3	y_4	y_5	y_6	y_7	u_1	u_2	u_3	u_4	u_5	u_6	u_7	u_8	e_j
0	u_1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	558
0	u_2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1,809
4214	y_3	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	442
0	u_4	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	149
3785	y_5	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1,209
5667	y_6	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1,050
0	u_7	-.6356	-.7022	0	-.6800	0	0	0	0	0	.9822	0	.9644	1.6	1	-.0044	1,735
3754	y_7	.6356	.7022	0	.6800	0	0	1	0	0	-.9822	0	-.9644	-1.6	0	.0044	3,387
		1301	586	0	447	0	0	0	0	0	-527	0	-164	339	0	-17	-25,101,965

Tableau 7

Coefficients of Solution Variables (p_j)	z_j Solution Variables	p_1 y_1	p_2 y_2	p_3 y_3	p_4 y_4	p_5 y_5	p_6 y_6	p_7 y_7	0 u_1	0 u_2	0 u_3	0 u_4	0 u_5	0 u_6	0 u_7	0 u_8	e_j
3687	y_1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	558
0	u_2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1,809
4214	y_3	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	442
0	u_4	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	149
3785	y_5	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1,209
5667	y_6	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1,050
0	u_7	0	-.7022	0	-.6800	0	0	0	.6356	0	.9822	0	.9644	1.6	1	-.0044	2,090
3754	y_1	0	.7022	0	.6800	0	0	1	-.6356	0	-.9822	0	-.9644	-1.6	0	.0044	3,032
		0	586	0	447	0	0	0	-1301	0	-527	0	-164	339	0	-17	-25,827,993

Tableau 8

		y_1	y_2	y_3	y_4	y_5	y_6	y_7	u_1	u_2	u_3	u_4	u_5	u_6	u_7	u_8	e_j
3687	y_1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	558
3222	y_2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1,809
4214	y_3	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	442
0	u_4	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	149
3785	y_5	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1,209
5667	y_6	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1,050
0	u_7	0	0	0	-.6800	0	0	0	.6356	.7022	.9822	0	.9644	1.6	1	-.0044	3,360
3754	y_7	0	0	0	.6800	0	0	1	-.6356	-.7022	-.9822	0	-.9644	-1.6	0	.0044	-1,762
		0	0	0	447	0	0	0	-1301	-586	-527	0	-164	339	0	-17	26,887,809

Tableau 9

Coefficients of Solution Variables (p_j)	z_j Solution Variables	p_1 y_1	p_2 y_2	p_3 y_3	p_4 y_4	p_5 y_5	p_6 y_6	p_7 y_7	0 u_1	0 u_2	0 u_3	0 u_4	0 u_5	0 u_6	0 u_7	0 u_8	e_j
3687	y_1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	558
3222	y_2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1,809
4214	y_3	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	442
3000	y_4	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	149
3785	y_5	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1,209
5667	y_6	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1,050
0	u_7	0	0	0	0	0	0	0	.6356	.7022	.9822	.6800	.9644	1.6	1	-.0044	3,461
3754	y_7	0	0	0	0	0	0	1	-.6356	-.7022	-.9822	-.6800	-.9644	-1.6	0	.0044	3,341
		0	0	0	0	0	0	0	-1301	-586	-527	-447	-164	339	0	-17	-26,954,454

Tableau 10

		y_1	y_2	y_3	y_4	y_5	y_6	y_7	u_1	u_2	u_3	u_4	u_5	u_6	u_7	u_8	e_j
3687	y_1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	558
3222	y_2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1,809
4214	y_3	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	442
3000	y_4	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	149
3785	y_5	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1,209
0	u_6	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1,050
0	u_7	0	0	0	0	0	-1.6	0	.6356	.7022	.9822	.6800	.9644	0	1	-.0044	1,781
3754	y_7	0	0	0	0	0	+1.6	1	-.6356	-.7022	-.9822	-.6800	-.9644	0	0	.0044	3,341
		0	0	0	0	0	-339	0	-1301	-586	-527	-447	-164	0	0	-17	-27,310,824

From the solution in tableau 10, the enrollment mix should then be adjusted such that:

y_1 = 558 enrollees will be added for the j = 1 skill

y_2 = 1809 enrollees will be added for the j = 2 skill

y_3 = 442 enrollees will be added for the j = 3 skill

y_4 = 149 enrollees will be added for the j = 4 skill

y_5 = 1209 enrollees will be added for the j = 5 skill

y_6 = 0 enrollees will be added for the j = 6 skill

y_7 = 3341 enrollees will be added for the j = 7 skill

for a budget allocation of 1,500,000 dollars. The total amount of entry level salary produced by this enrollment program mix change is 27,313,721 dollars.

The total number of enrollees required to fully satisfy the adjustment share could not be met due to the budget constraint of 1,500,000 dollars. This is indicated by the slacks u_6 and u_7 remaining in solution. The slack variables u_6 and u_7 mean that there are 1050 enrollees awaiting training for the j = 6 skill and 1781 enrollees awaiting training for the j = 7 skill who will not be trained unless more money is provided in the instructional budget or a trade-off is made to redistribute the budget differently. The additional amount required to train those identified by slack $u_6 = 1050$ would be 378,000 dollars and would generate an additional 5,950,350 dollars in entry level salary. The additional amount required to train those identified by slack $u_7 = 1781$ would be 400,725 dollars and would generate an additional 6,685,874 dollars in entry level salary. A sensitivity analysis can be used to determine the affect of enrollment trade-offs.

Sensitivity Analysis

The optimal solution for the linear program example has been determined as shown in tableau 10. However, the optimal solution may not be ideal for the real world problem. If it is found that there are some weaknesses in the initial solution, improvements can be made if it is known which of the variables are the most critical or most "sensitive". Sensitivity analysis is a procedure which can help to determine these critical variables. A sensitivity analysis will be performed to show the affect on the solution when a modification is made such that one variable value is changed. The data from the previous example will be used to demonstrate the analysis.

The variable e_5 will be used for the analysis which follows. Let e_5 be changed by an incremental amount Δe_5. With the data from tableau 10, the following partial derivatives can be written:

1. $\frac{\partial y_1}{\partial e_5} = 0$	4. $\frac{\partial y_4}{\partial e_5} = 0$	7. $\frac{\partial y_7}{\partial e_5} = -.9644$
2. $\frac{\partial y_2}{\partial e_5} = 0$	5. $\frac{\partial y_5}{\partial e_5} = 1$	8. $\frac{\partial u_7}{\partial e_5} = .9644$
3. $\frac{\partial y_3}{\partial e_5} = 0$	6. $\frac{\partial y_6}{\partial e_5} = 0$	9. $\frac{\partial z}{\partial e_5} = -164.$

The partial derivatives indicate that there will be zero change in variables y_1, y_2, y_3, y_4, and y_6 for any Δe_5.

Regrouping the variables which will change and rewriting to show the incremental relationships give:

1. $\frac{\Delta y_5}{\Delta e_5} = 1$

   $\Delta y_5 = \Delta e_5$

2. $\frac{\Delta y_7}{\Delta e_5} = -.9644$

   $\Delta y_7 = -.9644\ \Delta e_5$

3. $\frac{\Delta u_7}{\Delta e_5} = .9644$

   $\Delta u_7 = .9644\ \Delta e_5$

4. $\frac{\Delta z}{\Delta e_5} = 164$

   $\Delta z = 164\ \Delta e_5$.

Then, for any Δe_5, the value of the solution variables will be as shown below:

Variable	Value
y_1	558 + 0
y_2	1,809 + 0
y_3	442 + 0
y_4	149 + 0
y_5	1,209 + 1 Δe_5
u_6	1,050 + 0
u_7	1,781 + .9644 Δe_5
y_7	3,341 − .9644 Δe_5
z	27,313,721 + 164 Δe_5

The enrollment can never be a negative value; therefore, all variable values in the above listing must be ≥ 0 for a feasible solution to exist. To satisfy the non-negativity constraint, it follows that:

1. $1,209 + \Delta e_5 \geq 0$
2. $1,781 + .9644\ \Delta e_5 \geq 0$
3. $3,341 - .9644\ \Delta e_5 \geq 0$.

The range of feasibility can be determined by solving the inequalities in terms of Δe_5. This gives

1. $\Delta e_5 \geq -1209$
2. $\Delta e_5 \geq -1847$
3. $\Delta e_5 \geq 3464$.

Then the range of feasibility for Δe_5 is

$$3464 \geq \Delta e_5 \geq -1209.$$

Let $\Delta e_5 = 250$ enrollees; then the variables would take on the following values:

$y_5 = 1209 + 250 = 1459$

$u_7 = 1781 + .9644(250) = 2021$

$y_7 = 3341 - .9644(250) = 3100$

$z = 27{,}313{,}721 + 164(250) = 27{,}354{,}721.$

The interpretation of this analysis is that for the same budget of 1,500,000 dollars, the total amount of entry level salary generated would increase 410,000 dollars by enrolling 250 more persons in skill 5 and reducing the enrollment by 241 persons in skill 7.

Discussion of Constraints

The constraints on the enrollment in the illustrative problem were developed so that for any limiting budget B, the enrollment e_j in any education program would not be greater than the enrollment which is required to satisfy the adjustment share x_j for vo-tech. There are many different constraints from those illustrated which could have been placed on the problem. A few examples follow.

Example 1. It was decided for humanitarian reasons that the vo-tech system must have a minimum level of enrollees e_3 in health occupations. Then, constraint Equation (4) $y_3 \leq e_3$ would have to be changed and the new constraint Equation (4) would be $y_3 \geq e_3$.

Example 2. It was decided that the high cost training equipment for technical education must be fully utilized and the number of enrollees e_6 in technical education must be equal to the number which the training equipment can serve. Then, constraint Equation (7) $y_6 \leq e_6$ would have to be changed and the new constraint Equation (7) would be $y_6 = e_6$.

Example 3. To maintain harmony between two department managers in the vo-tech system it is required that the enrollment e_5 for office education must exceed the enrollment e_4 in home economics by 137 enrollees. That is $e_5 = e_4 + 137$. Then, constraint Equation (6) $y_5 \leq e_5$ would have to be changed and the new constraint Equation (6) would be $y_5 \leq e_4 + 137$.

Example 4. Federal manpower planners may feel that enrollment in agricultural training programs should never exceed 20 per cent of the total enrollment. It was decided for political reasons that agricultural enrollment will not exceed 20 per cent. Then, the following constraint can be added:

$$y_1 \leq .20(e_1 + e_2 + e_3 + e_4 + e_5 + e_6 + e_7).$$

Budget Non-Constrained Problem

In order to meet the total statewide adjustment $\sum_{j=1}^{j=7} x_j'$ for the seven skills, the vo-tech system must have $\sum_{j=1}^{j=7} y_j$ enrollees for the seven skills to provide its adjustment share. The total entry level salary is represented by $z = \sum_{j=1}^{j=7} p_j y_j$. Since there are no budget constraints, the problem is one of determining the value $z = \sum_{j=1}^{j=7} p_j y_j$ and the total instructional cost, $B = \sum_{j=1}^{j=7} c_j y_j$ subject to $y_j' = e_j'$.

The formulation is as follows:

$$\text{determine } z = \sum_{j=1}^{j=7} p_j y_j \quad ; \quad B = \sum_{j=1}^{j=7} c_j y_j$$

$$\text{subject to} \qquad y_j' = e_j'.$$

The symbols and data will remain as given in the previous linear programming problem except that the budget must be determined. Then,

$$B = c_1 y_1 + c_2 y_2 + c_3 y_3 + c_4 y_4 + c_5 y_5 + c_6 y_6 + c_7 y_7$$

and

$$z = p_1 y_1 + p_2 y_2 + p_3 y_3 + p_4 y_4 + p_5 y_5 + p_6 y_6 + p_7 y_7$$

substituting and solving gives

$$B = (143)(558) + (158)(1809) + (221)(442) + (153)(149) + (217)(1209) + (360)(1050) + (225)(5122)$$

$$B = 79{,}794 + 285{,}822 + 97{,}682 + 22{,}797 + 262{,}353 + 378{,}000 + 1{,}152{,}450$$

$$B = 2{,}278{,}898 \text{ dollars.}$$

$$z = (3687)(558) + (3222)(1809) + (4214)(442) + (3000)(149) + (3785)(1209) + (5667)(1020) + (3754)(5122)$$

$$= 2{,}057{,}346 + 5{,}828{,}598 + 1{,}862{,}588 + 447{,}000 + 4{,}576{,}065 + 5{,}950{,}350 + 19{,}227{,}988$$

$$= 39{,}949{,}935 \text{ dollars.}$$

The budget required for the vo-tech system to provide its adjustment share is 2,278,898 dollars and will generate a total of 39,949,935 dollars in entry level salary.

Data Acquisition and Computational Techniques

The numerical values of the variables used in the previous models are shown in Table II. The discussion in Chapter II showed that relatively little emphasis was devoted to statewide manpower planning until the passage of the Vocational Education Amendments of 1968 and that occupational information systems are still in the conceptual phase of development. The manpower problems confronting vocational and technical education planners are to determine what type of data is required, how to use it, and can it be acquired. The data shown in Table II are the type required for the model; one use of it is the linear program technique and the data can be acquired.

There are r = 7 j^{th} skill training programs in the

TABLE II

NUMERICAL VALUES OF THE VARIABLES USED IN THE MODEL

Program Service Division (j^{th} skill)	e_j Number of Students Enrolled	C_j Total Expenditure ($)	$c_j = \frac{C_j}{e_j}$ Cost Per Enrollee $/enrollee	L Average Training Program length in months	v_j Droupout Rate (%)	$1 - v_j$ Graduation Rate (%)	β_j Defection Rate (%)	$1 - \beta_j$ Available for Placement Rate (%)	α_j Adjustment Share (%)	X_j Statewide Adjustment $(D_j - S_j)$	x_j Vo-Tech Adjustment $(X_j)(\alpha_j)$	g_j Graduates $\frac{x_j}{1 - \beta_j}$	w_j Defectors $g_j - x_j$	e_j Enrollees $\frac{g_j}{1 - \gamma_j}$	f_j Dropouts $e_j - g_j$
1. Agriculture Education	24,034	3,426,203	143	34	55	45	71.7	28.3	90.4	78	71	251	180	558	307
2. Distributing and Marketing Education	2,973	470,577	158	19	36	64	59.4	40.6	25.7	1,829	470	1,158	688	1,809	651
3. Health Education	1,784	656,982	221	12	12	88	20.8	79.2	24.3	1,267	308	389	81	442	53
4. Home Economics Gainful Education	1,792	275,010	153	32	23	77	73.0	27.0	6.6	463	31	115	84	149	34
5. Office Education	4,731	1,027,763	217	15	29	71	52.1	47.9	14.7	2,796	411	858	447	1,209	762
6. Technical Education	5,593	2,011,685	360	19	58	42	72.8	27.2	42.5	282	120	441	321	1,050	609
7. Trades and Industry Education	16,954	3,813,918	225	22	58	42	49.8	50.2	32.2	3,355	1,080	2,151	1,071	5,122	2,971

vocational and technical education system in Oklahoma. These include Agriculture Education, Distributive and Marketing Education, Health Education, Home Economics Gainful and Useful Education, Office Education, Technical Education and Trades and Industry Education. The Home Economics Useful program is devoted to home and family living and consumer education. It does not lend itself to labor market analysis and was excluded from consideration.

The trades and industry education program will be used as an example to show how the values listed for the variables contained in Table II were derived.

VARIABLE 1 - Statewide adjustment variable X_j

CALCULATION - $X_j = D_j - S_j$

$$X_j = 9692 - 6337$$

$$X_j = 3355$$

AVAILABLE DATA SOURCE - Oklahoma Occupational Training Information System

DISCUSSION OF DATA SOURCE - The occupational training information system was conceptualized in May 1968 and formally established in 1969. The purpose was to establish systematic procedures for identifying, collecting, and analyzing data for statewide manpower planning purposes in Oklahoma. In the summer of 1969, a special labor market survey was conducted for the State of Oklahoma. The demand and supply data were acquired from this survey. The OTIS system has been placed under the Director of Vocational and Training Education and plans to collect this type of demand and supply data annually or as necessary.

SUMMARY - A means for acquiring data for x_j is available.

VARIABLE 2 - Per cent adjustment share α_j

CALCULATION - $\alpha_j = \frac{s_j}{S_j}$

$$\alpha_j = \frac{2041}{6337}$$

$$\alpha_j = .322$$

AVAILABLE DATA SOURCE - Oklahoma Occupational Training Information System

DISCUSSION OF DATA SOURCE - A joint committee representing all the major sources of supply in Oklahoma has been established. The adjustment share can be determined quantitatively for agreement by the committee or can be qualitatively determined through negotiation.

SUMMARY - A means for determining α_j is available.

VARIABLE 3 - Absolute value of adjustment share x_j

CALCULATION - $x_j = X_j \alpha_j$

$$x_j = (3355)(.322)$$

$$x_j = 1080$$

SUMMARY - The absolute value of adjustment share X_j is a calculation using data previously explained.

VARIABLE 4 - Rate of defection β_j.

CALCULATION - $\beta_j = \frac{w_j}{g_j}$

$$\beta_j = \frac{441}{886}$$

$$\beta_j = .498$$

DATA SOURCE - Oklahoma Occupational Training Information System and Department of Vocational and Technical Education.

DISCUSSION OF DATA SOURCE - The graduate follow-up subsystem has the responsibility to collect follow-up data on vocational and technical training graduates for studies of mobility patterns on a longitudinal basis.

SUMMARY - The first major statewide graduate follow-up was in the summer of 1969. The continuous collection of this data will increase the validity of the rate of defection estimate. A means for determining β_j is available.

VARIABLE 5 - Incremental number of graduates needed g_j.

CALCULATION - $g_j = \frac{x_j}{1 - \beta_j}$

$$g_j = \frac{1080}{1 - .498}$$

$$g_j = 2151$$

SUMMARY - The incremental number of graduates required is a calculation using data previously explained.

VARIABLE 6 - Dropout rate γ_j

CALCULATION - $\gamma_j = \frac{f_j}{e_j}$

DISCUSSION - An accurate record of the number of dropouts for the vocational and technical education system by program category has not been kept in the past. Therefore, no reliable trend data for dropouts presently exists. The occupational training information staff is considering collecting this type data. However, a survey was made in the fall of 1969 by the Research Coordinating Unit of the

Vocational and Technical Education Department. From this survey data, an estimate of dropout rate was computed, however its validity cannot be determined.

The following procedure was used to compute dropout rates for the seven service divisions listed in Table II:

1. Data collection on dropout is described below:
    a. In the fall of 1968, 53,292 students in occupational training was identified on OTIS Form 2's.
    b. The Research Coordinating Unit followed up 44,758 of these students one year later in the fall of 1969.
2. The number of dropouts that occurred in the one-year period was computed for each service division. Dropouts were defined as students who (1) had been identified in the fall of 1968 as enrollees, (2) had been followed-up in the fall of 1969, (3) were not still enrolled in the fall of 1969, and (4) had not graduated. The length of time the enrollee was in the program was not known.
3. From the sample, a <u>yearly</u> dropout rate y was computed for each service division by dividing the number of dropouts by the number followed-up in the particular service division. A year was defined as a nine-month academic period for all service divisions except health education

where 12 months constituted a year.

4. The average length of the programs in months was computed from the Student Characteristics Tape of OTIS data for each program service division. These ranged from 12 to 34 months.

5. The <u>over-all</u> program service division dropout rate was computed for each service division using the yearly dropout rate over the number of years of the program length.

<u>Sample Calculation</u>: In the trades and industry program division, 8000 students were followed up and 2382 were found to have dropped out of the program. This gave a nine-month period or yearly dropout rate of 30 per cent ($\frac{2382}{8000} = .30$). This program division was 22 academic months in length, therefore there were $\frac{22}{9} = 2\frac{4}{9}$ yearly periods where the 30 per cent dropout rate occurred. Then, in the first nine months of the program, 30 per cent of the students will drop out and 70 per cent will remain, therefore leaving (.70 x 8000) = 5,600 enrolled in the course. By the end of the second period, another 30 per cent will have dropped out, therefore leaving (.70 x 5600) = 3,920 remaining in the course. Then, for the last period of the training program, $\frac{4}{9}$ of 30 per cent of the remaining students will drop out and 86.68 per cent will remain, therefore leaving (.8668 x 3920) 3397 students who are the graduates. Therefore, (8000 - 3397) = 4603 of the original students dropped out.

Then, the over-all dropout rate $\frac{4603}{8000}$ was 57.5 per cent.

6. The following expression was developed to calculate the over-all dropout rate for the program service division to fit the sample data.

$$\gamma = \sum_{k=1}^{n} y(1-y)^{k-1} + \frac{r}{9}\,(y)(1-y)^{n}$$

where γ is the over-all dropout rate over the average program length

y is the nine month yearly dropout rate

n is the number of whole y periods in the average program length

$\frac{4}{9}$ is the fractional part of the y period remaining after the n^{th} whole period.

SUMMARY - There is no formally established procedure or reliable records for determining dropout rates for the vocational and technical education system. Dropout rate is necessary for effective statewide manpower planning. It affects the output level of graduates necessary for meeting the statewide demand. It can be used to indicate the state of the training system at a point in time and can be used to aid the guidance function control the system. The occupational training information system is considering the collection of dropout data.

VARIABLE 7 - Cost per enrollee c_j

CALCULATION - $c_j = \frac{C_j}{e_j}$

$$c_j = \frac{3,813,918}{16,954}$$

$$c_j = 225$$

AVAILABLE DATA SOURCE - The Department of Vocational and Technical Education

DISCUSSION OF DATA SOURCE - The Department of Vocational and Technical Education is required to submit the total expenditure and total enrollment, by training program service division on OE Forms 4048 and OE Form 4043, rev. 2-69, to the Department of Health Education and Welfare in Washington, D.C. annually. Enrollment and cost data is readily attainable.

SUMMARY - A means for determining c_j and e_j is available.

The occupational training information system in Oklahoma has been established to collect and analyze data which is necessary for effective statewide manpower planning. The type of data required by the linear programming model is presently being obtained. Therefore, the algorithm can be used to aid in more effective decision making by the vocational and technical education system managers.

Control Technique

The recent development of the Occupational Training Information System (OTIS) in Oklahoma and the decision to place the system under the direct control of the Director of Vocational and Technical Education should increase the effectiveness of statewide manpower planning in Oklahoma.

This system has the capability to collect and analyze statewide manpower data, which up to now did not exist. Meaningful data on number of dropouts by training program, the time period when the dropout occurred, and training program lengths are examples of historical data which are not readily available. Data of this type is necessary for establishing control procedures for the system and determining the state of the system at any period of time. Dropout data and program length data are not difficult to collect. The occupational training information staff can be the focal point responsible for collecting and analyzing this data. A control model will be presented to demonstrate how it can help improve statewide manpower planning.

Concepts of Control Charts for Monitoring the Dropout Rate

The discussion of control charts will be used to acquaint the vocational and technical education administrators, who may be establishing a control procedure for the first time, with the fundamental principles of control as it relates to their system. The word "control" represents a management tool that may be used for setting the quality standards of the trainees, appraising conformance to these standards, taking action when these standards are exceeded and planning for improvement in the standards (40, p. 1). American industry has used several control methods effectively for many years. The control chart gives evidence regarding the quality level, its variability, and the presence or absence of assignable causes of variations (41, p. 281). This is useful information that can be used as a basis for improvement in other fields besides industry. The vocational and technical education is considered a likely candidate for being one of these other fields.

For the vocational and technical education system, the number of enrollees that dropout during the training program affects the output quantity of graduates available for gainful employment in skill occupations. Therefore, the dropout rate will be the selected variable to determine if the system is in control or out of control. Attribute sampling is appropriate to use for monitoring numbers of dropouts. When a record is kept to show only the number or articles conforming and the number of articles failing to conform to any specified requirements, it is said to be a record by attributes (41, p. 5). For the vocational training system, the original enrollee "is" or "is not" in the training program at the time of inspection. The original enrollees which are still in the program are the trainees and the remainder who are not in the program are the dropouts.

In the case of industrial systems, the measured quality of a manufactured product is always subject to a certain amount of variation as a result of chance. Some stable "system of chance causes" is inherent in any particular scheme of production and inspection. Variation within this stable pattern is inevitable. The reason for variation outside this stable pattern may be discovered and corrected (40, p. 3). The vocational and technical education system can reasonably be assumed to be analogous to a manufacturing production system since it has an input of untrained products which undergoes certain processes and is converted to a trained skilled product output with different characteristics that it had upon entrance to the system. Consequently, there is an inherent variation in the training activity that is considered to result from a constant cause system. That is, as the system (school, location, selection instruments, teachers, equipment, and so forth) stands, variation between certain limits is expected. The upper and lower control limits ($\pm 3\sigma$) will be used to define the region, between which the variation is considered to result from a constant cause system. It has been found in practice that the $\pm 3\sigma$ limits does include the vast majority of the inherent variability and for the normal curve this would be 99.73 per cent of the region of inherent variability. It is in this region, where the inherent variation exists, that no action is taken to determine the cause of the variation and no attempt is made to remove the cause. If, however, the dropout rate between these limits is not acceptable to the vo-tech management, then the control system must be changed. The area outside the control limits is the region that indicates an assignable cause of variation exists. When a sample dropout rate value falls outside the control limits, the indication is that an assignable cause of variation exists and a search to determine the cause should be conducted in an effort to bring the out of control system back into control. Whatever is done about the cause will be based upon the nature of the cause.

The rule for establishing the control limits is not rigid. The control limits are generally established at the value of the mean plus and minus 3 standard deviations ($\bar{p} \pm 3\sigma_p$) for industrial systems. The important aspect is that the limits selected should be practical for the system, and be based upon some point of economic balance. If the control limits are set too narrow, then a sample point falling outside the limits would require a search for determining the cause of trouble when actually there is no trouble. When the control limits are too wide, a sample point may fall within the limits and it erroneously indicates that the system is not in trouble when it is truly in trouble. The economic trade-off between the cost which would be incurred if these two errors unknowingly exist, and the cost to search when a search is not required, should be considered in establishing the control limits. Figure 8 will be used to clarify the concepts developed thus far. The calculation procedures will be explained later in the chapter.

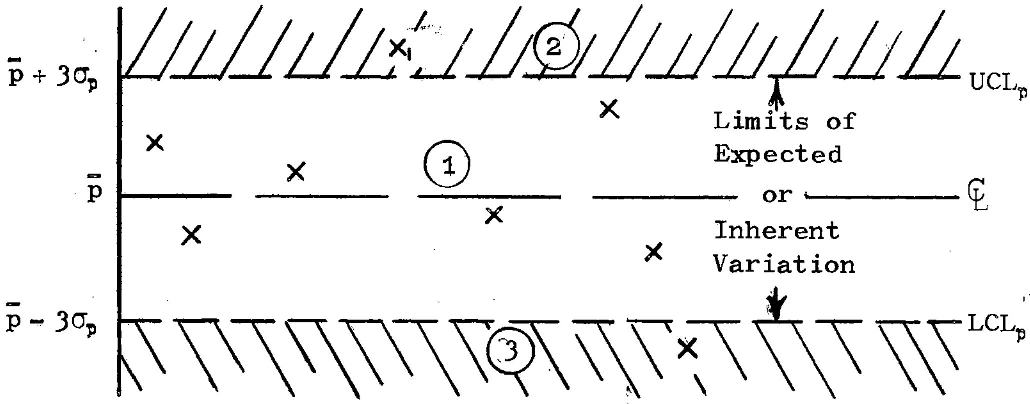

Figure 8. Illustrates a Control Chart for the Office Education Training Program

The mean dropout rate, which is the center line for the office education training program, is $\bar{p}$. The value of $\bar{p}$ has been determined from historical data collected over a long duration of time and is considered to be a valid estimate of the true mean of the system. The $\bar{p}$ is then the expected rate of dropouts that will occur in future office education programs. The upper control limit for the expected or inherent variation was determined to be 3 standard deviations above the mean ($\bar{p} + 3\sigma_p$). This value is shown at the upper portion of the chart. The lower control limit for the expected or inherent variation was determined to be 3 standard deviations below the mean ($\bar{p} - 3\sigma_p$). This value is shown at the lower portion of the chart. These values then define the limits of expected, inherent, or chance variation (region ①) and the regions of unexpected, non-inherent, non-chance, or causal variation (regions ② and ③). When the plotted sample dropout rate value lies in region

(1), the system is considered to be in control. Meaning that this is the usual variation due to chance alone that the vo-tech system manager has learned to expect and is considered to result from a constant cause system. No action is taken to correct the system at this time. This is shown by the x points on the chart. When the plotted sample drop-out rate value lies in region (2) or (3), the system is considered to be out of control. This implies that there is unusual variation which the vo-tech system manager has learned not to expect and is not considered to result from a constant cause system. Action should be taken to determine the cause of this assignable variation which is not considered to be due to chance alone. Dependent upon the nature of the cause, an effort should be made to correct the cause which forced the system to go out of control.

The control chart is not a panacea for the decision makers in vocational and technical education. It is a proven technique for basing decisions on quantitative estimates. The validity of the decisions made will depend upon the qualifications and skills of the user. The control chart merely provides an orderly system for monitoring, interpreting and analyzing data to assist in making practical conclusions. The conclusions reached are the responsibility of the decision maker. Therefore, the vo-tech system should attempt to assure that a competent, qualified person, who has been trained in the use of control charts, is assigned the responsibility for the control chart analysis. In summary, the control chart for the vocational and technical education system is a chronological graphical comparison of the actual dropout characteristics of the original enrollment in a designated training program, bounded by control limits which reflect the ability to produce skilled graduates as shown by past experience on the dropout characteristic of the training program being considered.

Interpretation of the Control Chart for Vocational and Technical Education

The recruiting, selection and training activities previously defined for vo-tech have an affect on the dropout characteristics of the system. When the control chart indicates that the system is in control, then a stable pattern of variation exists. This infers that the activities are performing as expected and no unusual causal factors are apparently present which require immediate action. The system is merely reacting as predicted. The conclusion that can be drawn is that the selection instruments, the teachers, training equipments, method of instruction, and so forth are performing as expected. A word of caution, the indication that the system is in control should not be interpreted to indicate that the normal management function of inspection, supervision, constant improvement effort and so forth can be relaxed. The <u>normal</u> management function required to improve its product and methods should still continue.

When the control chart indicates that the system is out of control by a point falling above the upper control limit, the following vo-tech conclusion may be drawn. The dropout rate is greater than was expected or that the people are not reporting the data correctly. The possible causes for this increased dropout rate are numerous. A change in training equipment, training method, teacher attitude, social conditions or economic conditions of the country and so forth may have been responsible. The cause may be such that it is not economically feasible or possible to make changes which would reduce the dropout rate and bring the system back into control. An example might be that the military draft quota was increased and the trainees were conscripted into the armed forces. The vo-tech manager can do little to remedy a cause such as this. However, if the cause of the high dropout rate was attributed to antiquated training aids and methods of instruction, then a change could be adopted to update the training aids and instruction methods in an effort to bring the system back into control.

A point falling out of control below the lower control limit indicates that the dropout rate is less than predicted. The vo-tech manager should not erroneously conclude that his system has improved. The search for causal factors is still required. For example, a temporary large demand for a certain skill in the employment sector may have increased the entry level salary for graduates from this program and motivated this group to remain in the system until graduation. The causal factor was not in the system itself. Another cause may be that the appraisal standards for student achievement were not applied in the proper manner with the result that many students remained in the system which would have been eliminated had the standards been properly applied. The quality level of skill was lowered while the quantity of output was increased. When points fall outside the control limits, and especially for the lower limit, if this is expected to remain the same then the mean dropout rate should be revised for future use. These are but a few interpretations that can be made by the vocational and technical education users of the control chart.

Two Approaches to Control Charts for Vocational and Technical Education

Two basic approaches can be taken for the design of a control chart for the vocational and technical education system. The first approach is to establish the control chart on the basis that the mean dropout rate will vary for different time periods of the training program. The second approach is to consider a control chart for which the mean dropout rate is based on the entire training program. Illustrative control charts will be developed for both of these approaches.

An estimate of the mean dropout rate $\bar{p}$ is the first requirement for the construction of a control chart. The estimate of the mean dropout rate $\bar{p}$ can be obtained from past data. Since this type data is not readily obtainable, it is recommended that the following procedure be adopted by the Oklahoma Occupational Training Information System (OTIS) for the collection of the required data:

1. Have each school report the type of training program being offered, the length of the training program, the initial start date, and the initial enrollment size.
2. Have each school keep continuous records over the entire program length of the number of dropouts and the date of the dropout. This will then determine the enrollment size at any time in the program.
3. This data can then be used to estimate the mean dropout rate. Subsequent data can then be used to monitor a particular training program(s).

Approach I

Once the mean dropout rate has been estimated, the calculation of the control limits can be made. The upper control limit (UCL_p) is the sum of the mean dropout rate and three standard deviations ($\bar{p} + 3\sigma_p$). The lower control limit (LCL_p) is the difference between the mean dropout rate and three standard deviations ($\bar{p} - 3\sigma_p$). Then,

(a) $UCL_{p_x} = \bar{p}_x + 3\sigma_{p_x}$ (c) $\sigma_{p_x} = \sqrt{\frac{p_x(1-p_x)}{n}}$

(b) $LCL_{p_x} = \bar{p}_x - 3\sigma_{p_x}$ (d) $\bar{p}_x = \frac{d_x}{n_x}$

where

$\bar{p}_x$ is the estimated mean dropout rate for the x period.

σ_{p_x} is the estimated standard deviation for the x period of time considered.

x is some selected period in the program.

n_x is the size of the enrollment at the start of the x period.

d_x is the number of dropouts which occurred during the x period.

UCL_{p_x} is the upper control limit.

LCL_{p_x} is the lower control limit.

These expressions will be used to provide a numerical illustration of a control chart having a varying mean dropout rate with the associated control limits for each period over the program length. Figure 9 is a general illustration of this type of control chart.

Figure 9 shows that the training program has been subdivided into four periods and for each period the mean dropout rate and associated control limits are also shown. The number of enrollees at the beginning and end of each period is depicted at the bottom of the chart.

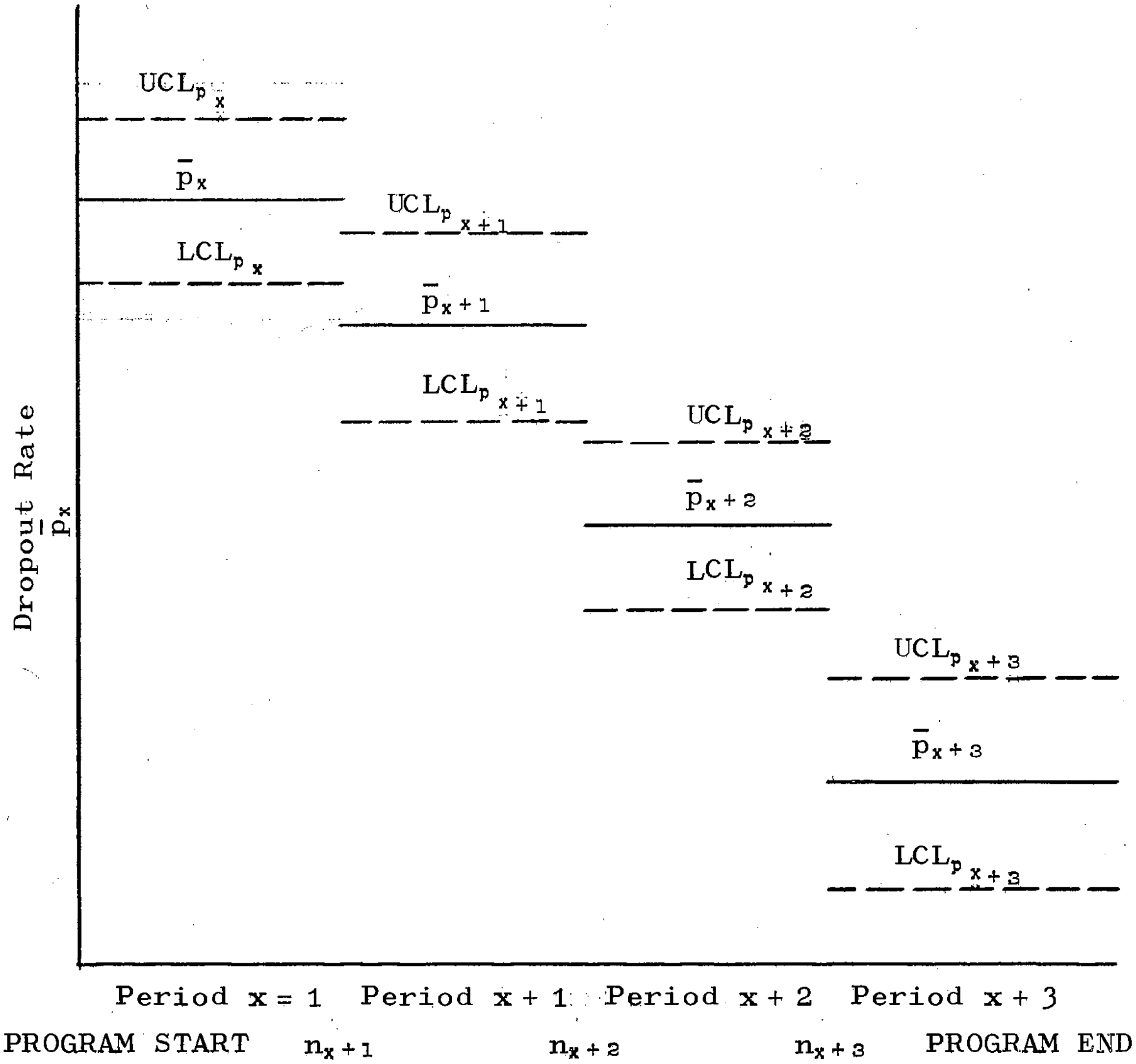

Figure 9. An Illustrative Control Chart With a Varying Mean Dropout Rate for Each Period of the Program Duration

The following example, using hypothetical data, will be used to show the procedure required for developing the control chart. Since reliable trend data is not readily available, it will be assumed that it was found to be true from past data that a reliable estimate of the mean dropout rates $\bar{p}_x$ for each of the four periods x of the training program are $\bar{p}_1 = .2200$, $\bar{p}_2 = .2000$, $\bar{p}_3 = .1900$, and $\bar{p}_4 = .1200$. These estimates of the mean dropout rates are then plotted to begin the construction of a control chart as shown in Figure 10.

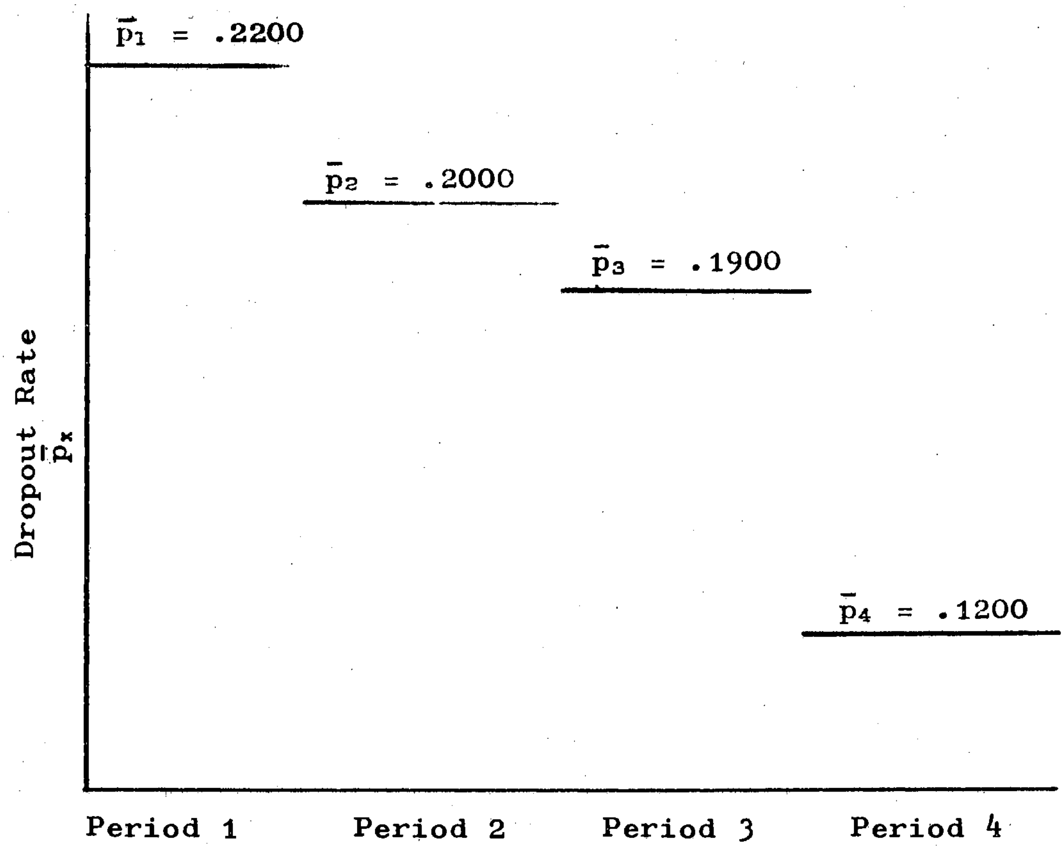

Figure 10. A Plot of the Mean Dropout Rate Estimates for Each Period of the Training Program

The data required for the use of the control chart are listed in Table III.

TABLE III

LIST OF DATA FOR USE FOR THE CONTROL CHART WITH A VARYING MEAN FOR EACH PERIOD

Period	n_x	d_x	$\bar{p}_x = \frac{d_x}{n_x}$	$\bar{p}_{x_0}$	$\sigma_{p_{x_0}} = \frac{\sqrt{\bar{p}_{x_0}(1-\bar{p}_{x_0})}}{\sqrt{n_x}}$	$3\sigma_{p_{x_0}}$	$UCL_{p_{x_0}} = \bar{p}_x + 3\sigma_{n_{x_0}}$	$LCL_{p_{x_0}} = \bar{p}_x - 3\sigma_{p_{x_0}}$
1	7481	1739	.2325	.2200	.0048	.0144	.2344	.2056
2	5742	1218	.2121	.2000	.0053	.0159	.2159	.1841
3	4524	802	.1773	.1900	.0058	.0174	.2074	.1726
4	3722	493	.1325	.1200	.0053	.0159	.1359	.1041
5	3229	---	---	---	---	---	---	---

This data was determined in the following manner. The initial enrollment of 7481 students could be derived from records which the schools would have submitted to the occupational training information staff. The number of dropouts reported at the end of the first period was 1739. Then, the dropout rate for the first period was:

$$p_1 = \frac{d_1}{n_1}$$

$$p_1 = \frac{1739}{7481}$$

$$p_1 = .2325.$$

This value is then plotted on the control chart in the first time period. The control limits are next calculated to determine the state of the system. Then,

$$UCL_{p_{x_o}} = \bar{p}_{x_o} + 3\sqrt{\frac{\bar{p}_{x_o}(1-\bar{p}_{x_o})}{n_x}}$$

$$UCL_{p_{x_o}} = .2200 + 3\sqrt{\frac{.22(1-.22)}{7481}}$$

$$UCL_{p_{x_o}} = .2344$$

and

$$LCL_{p_{x_o}} = \bar{p}_{x_o} - 3\sqrt{\frac{\bar{p}_{x_o}(1-\bar{p}_{x_o})}{n_x}}$$

$$LCL_{p_{x_o}} = .2200-3\sqrt{\frac{.22(1-.22)}{7481}}$$

$$LCL_{p_{x_o}} = .2056.$$

These control limits are plotted on the control chart and an assessment of the state of the system can be made. If the plotted value $p_1 = .2325$ is not outside the control limits, then the system is in control and this indicates that no search for causal factors are required. If the value $p_1 = .2325$ lies outside the control limits, then the indication is that the system is out of control and a search for causal factors should be taken.

A plot of the data as shown in Figure 11 indicates that the point (p_1) is in control.

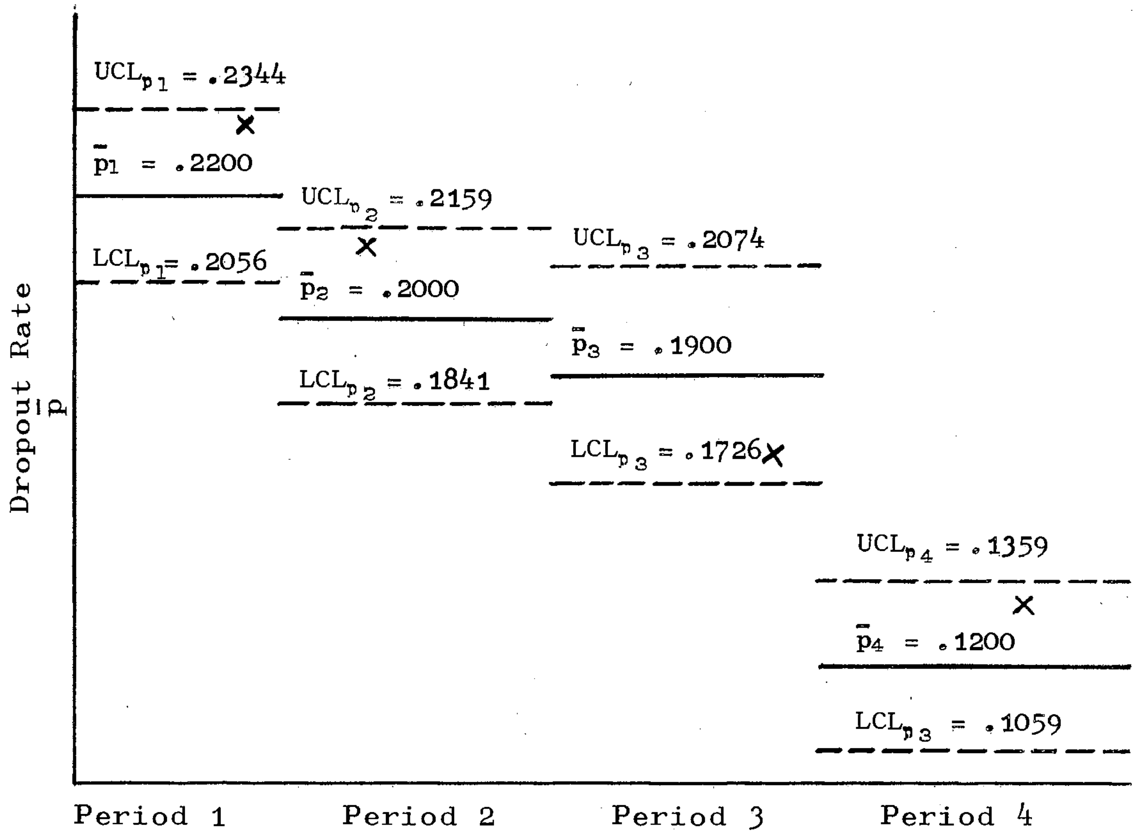

Figure 11. Control Chart for the Numerical Example

The number of enrollees at the start of the second period is the number of enrollees who were enrolled at the beginning of the first period minus the number who dropped out during the period. That is,

$$n_2 = n_1 - d_1$$

$$n_2 = 7481 - 1739$$

$$n_2 = 5742.$$

However, if there is an elapse of time between the periods n_x and n_{x+1}, where some dropouts may occur, then the enrollment value that should be used for the calculations is the value of the enrollment at the start of the n_{x+1} period.

The calculation procedure for determining the state of the system for the second period will be the same procedure as was used in the calculations made for first period. That is, the p_2 is calculated and plotted; then, the control limits are determined and placed on the control chart and an analysis is made to ascertain the state of the system. This procedure is repeated until the state of the system has been evaluated for all the periods of the training program. The calculated values for all four periods of the example problem appear in Table III. The plot of the dropout rates for each period are shown in Figure 11 and all the points are in control.

The over-all graduate rate and dropout rate can be determined at the end of the last period of the training program. The value n_5 in Table III is the number of graduates of the training program. Then,

$$\text{Graduate rate} = \frac{\text{number of graduates}}{\text{number of original enrollees}}$$

$$\text{Graduate rate} = \frac{3229}{7481}$$

$$\text{Graduate rate} = .4316.$$

The over-all dropout rate for the training program is equal to the graduate rate subtracted from one. Then,

$$\text{over-all dropout rate} = 1 - \text{graduate rate}$$

$$\text{over-all dropout rate} = 1 - .4316$$

$$\text{over-all dropout rate} = .5684.$$

The use of this varying mean dropout rate control chart can provide valuable assistance to the decision makers of the vocational and technical education system. The application of this chart, especially relative to long duration training programs, should provide an effective mechanism for system control.

Approach II

The second approach for the development of a control chart is to base the dropout rate over the entire length of a program. This results in the constant mean dropout rate. Hypothetical data will be used to develop the control chart with a constant mean dropout rate estimate over the entire program.

The data over the past five cycles for which the training program was offered is as shown below.

Cycle	Enrollment	Dropouts
1	3948	1533
2	4107	1611
3	3711	1816
4	4001	1903
5	3879	1679
	19646	8542

Then, the average dropout rate $\bar{p}$ can be determined by

$$\bar{p}o = \frac{\sum_{i=1}^{i=5} d_i}{\sum_{i=1}^{i=5} e_i}$$

where

$\bar{p}_o$ is the average dropout rate of the program.

p_i is the dropout rate for the i^{th} cycle.

e_i is the enrollment for the i^{th} cycle.

d_i is the number of dropouts for the i^{th} cycle.

i is the program cycle.

Then,

$$\bar{p}_o = \frac{8,542}{19,646}$$

$$\bar{p}_o = .4348.$$

The generalized control chart would be as shown in Figure 12. A cycle is defined as the start and end of a training program.

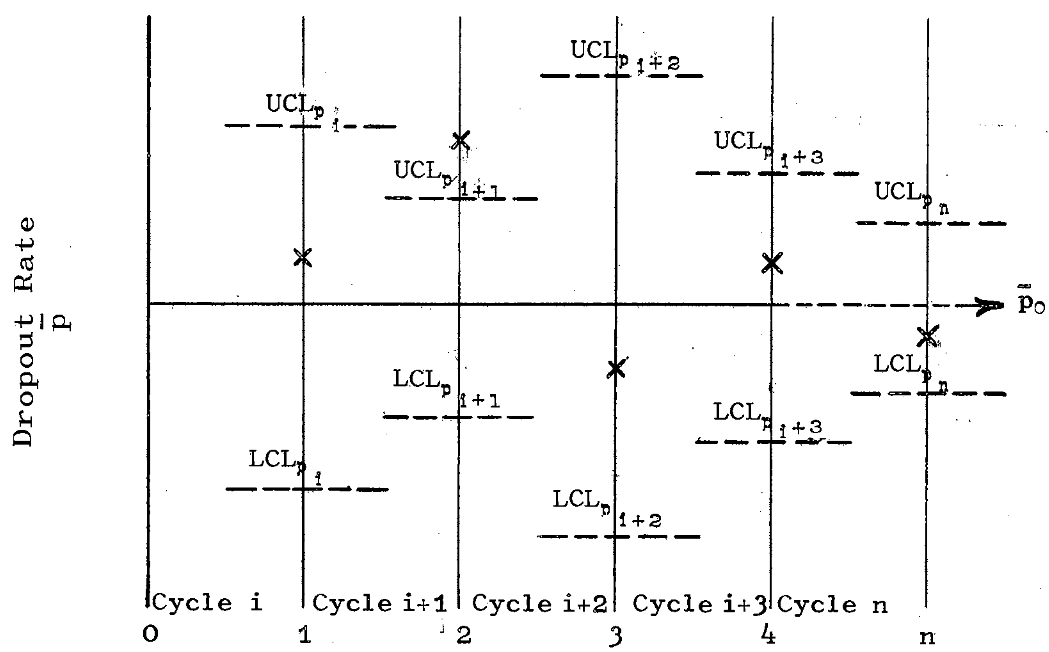

Figure 12. Control Chart for a Training Program Having a Constant Mean Dropout Rate Estimate

This chart will be used to determine if the dropout rate from the training program just completed is what should be expected. The method used to make this determination is to calculate the dropout rate for the program being considered; plot the value $\bar{p}_o$ on the control chart; solve for the control limits and analyze the chart.

If after the sixth cycle for which the training program was offered, it was desired to know if the program dropout rate for this cycle was such that would be expected. The use of the data derived for the past five cycles could then be used to provide an answer to this question. With the average dropout rate over the past five cycles previously calculated to be $\bar{p}_o = .4548$, a control chart can be developed using this $\bar{p}_o$ as an estimate of the mean dropout rate for the sixth and succeeding cycles. Cyles 6 through 10 have been arbitrarily chosen as the cycles to be analyzed. Table IV lists the data which was sequentially derived at the end of each cycle. An analysis of the system state was hypothetically made at the end of each training program cycle. The values listed in Table IV were calculated in the following manner.

TABLE IV

DATA FOR THE 6 THROUGH 10 CYCLES
OF THE TRAINING PROGRAM

Cycle	Enroll-ment	Drop-outs	Drop-out Rate	Upper Control Limit	Lower Control Limit
6	3893	1813	.4657	.4585	.4111
7	3698	1631	.4410	.4592	.4104
8	4291	1886	.4395	.4575	.4121
9	3764	1657	.4402	.4590	.4106
10	4317	1926	.4461	.4574	.4122

The mean dropout rate for cycle 6 was:

$$p_6 = \frac{d_6}{e_6}$$

$$p_6 = \frac{1813}{3893}$$

$$p_6 = .4657.$$

The control limits are then

$$CL_{p_6} = \bar{p}_0 \pm 3\sqrt{\frac{\bar{p}_0(1-\bar{p}_0)}{n_x}}$$

$$UCL_{p_6} = .4348 + 3\sqrt{\frac{.4348(1-.4348)}{3893}}$$

$$UCL_{p_6} = .4348 + 3(.0079)$$

$$UCL_{p_6} = .4585$$

$$LCL_{p_6} = .4348 - 3\sqrt{\frac{.4348(1-.4348)}{3893}}$$

$$LCL_{p_6} = .4348 - 3(.0079)$$

$$LCL_{p_6} = .4111.$$

Then,

$$p_7 = \frac{1631}{3698}$$

$$p_7 = .4410$$

$$UCL_{p_7} = .4348 + 3\sqrt{\frac{.4348(1-.4348)}{3698}}$$

$$UCL_{p_7} = .4348 + .0244$$

$$UCL_{p_7} = .4592$$

$$LCL_{p_7} = .4348 - .0244$$

$$LCL_{p_7} = .4104.$$

Then,

$$p_8 = \frac{1886}{4291}$$

$$p_8 = .4391$$

$$UCL_{p_8} = 4348 + 3\sqrt{\frac{(.4348)(1-.4348)}{4291}}$$

$$UCL_{p_8} = .4348 + .0227$$

$$UCL_{p_8} = .4575$$

$$LCL_{p_8} = .4348 - .0227$$

$$LCL_{p_8} = .4121.$$

Then,

$$p_9 = \frac{1657}{3764}$$

$$p_9 = .4402$$

$$UCL_{p_9} = .4348 + 3\sqrt{\frac{.4348(1-.4348)}{3764}}$$

$$UCL_{p_9} = .4348 + .0242$$

$$UCL_{p_9} = .4590$$

$$LCL_{p_9} = .4348 - .0242$$

$$LCL_{p_9} = .4106.$$

Then,

$$p_{10} = \frac{1974}{4317}$$

$$p_{10} = .4573$$

$$UCL_{p_{10}} = .4348 + 3\sqrt{\frac{.4348(1-.4348)}{4317}}$$

$$UCL_{p_{10}} = .4348 + .0226$$

$$UCL_{p_{10}} = .4574$$

$$LCL_{p_{10}} = .4348 - .0226$$

$$LCL_{p_{10}} = .4122.$$

The plot of the data is shown in Figure 13 which is the control chart developed to analyze the data.

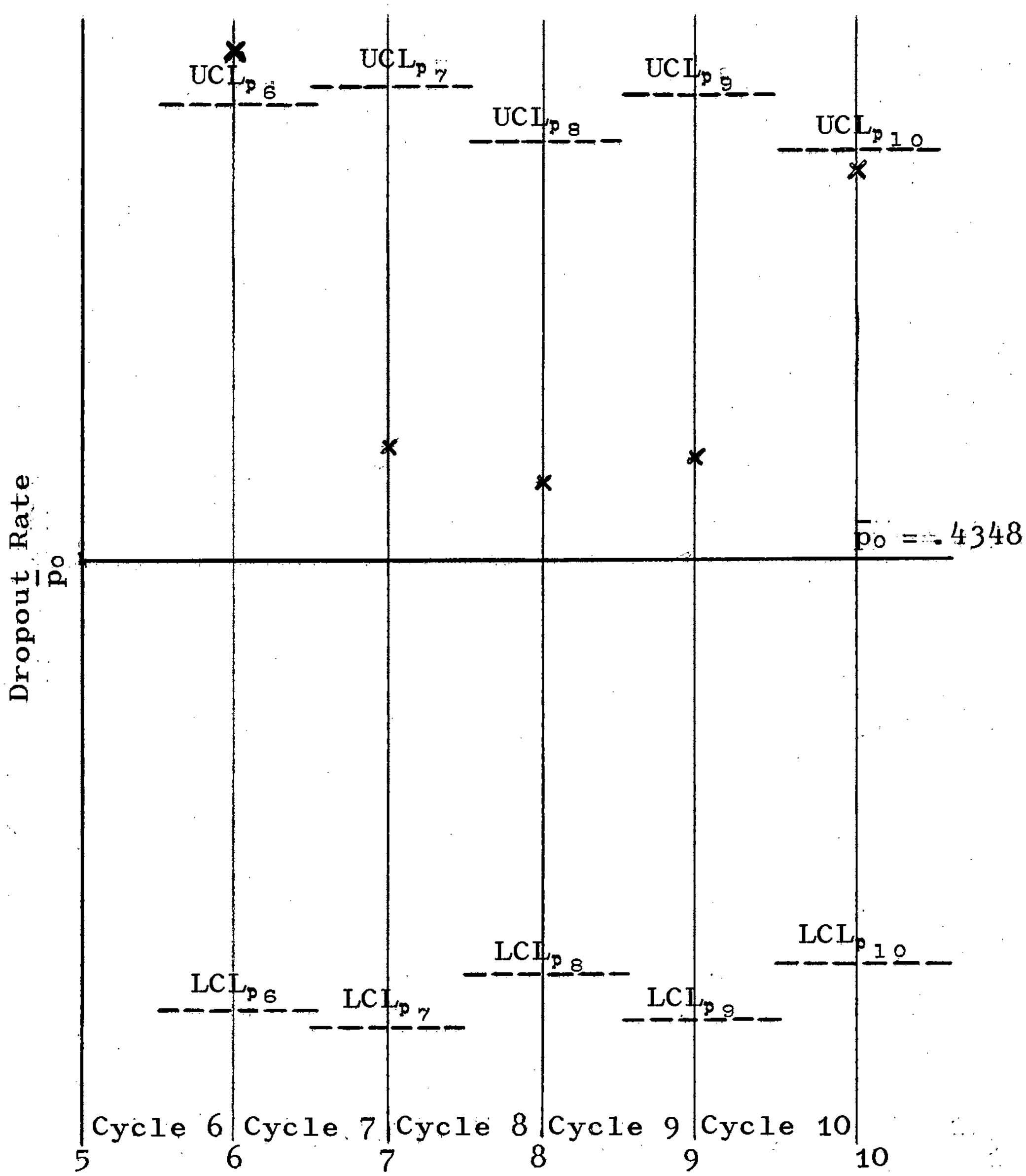

Figure 13. Control Chart With the Plot of Data for Cycles 6 Through 10

The dropout rate p_6 for cycle 6 plots above the upper control limit. This is interpreted to mean that the dropout rate was higher than would be expected. A search for causal factors should be conducted. The dropout rates p_7, p_8, p_9, and p_{10} plotted in the region of expected variation. The indication is that the dropout rates which occurred were within the tolerance range of what would be expected. However, an analysis of the control chart indicates that for four consecutive cycles, the dropout rates p_7, p_8, p_9, and p_{10} were above the mean value $\bar{p}_0 = .4348$. This could indicate the possibility that the system has changed. An analysis should be made to determine if a system change occurred so that the mean dropout rate $\bar{p}_0 = .4348$ can be adjusted accordingly so as to provide a more valid dropout estimate for evaluating succeeding program training cycles.

The use of the control chart procedure is equally applicable for all levels of management in the vocational and technical education hierarchy. The two control charts developed in this chapter can be used on a statewide, regional, local, or individual school level. The level of control desired will not decrease the validity of the control procedures developed in this chapter. The level of control desired is left to the discretion of the managers in the vocational and technical education system.

CHAPTER V

SUMMARY AND CONCLUSIONS

This concluding chapter is composed of three sections. The first section is devoted to a summary of the concepts presented in each chapter of the study. The second section relates to the answers of the research questions proposed in this treatise. The last section presents proposals for possible future research related to the model developed in this dissertation and to the general area of vocational and technical education.

Summary

A decision model which describes the vocational and technical education system was developed. The model provides a framework for identifying, classifying, and analyzing data related to statewide manpower planning. A systematic procedure was developed to identify the functions, activities, and variables which affect the making of decisions in the vocational and technical education system. The model is simply a manpower accounting procedure. It is a powerful and useful tool which should assist in more effective statewide manpower planning. It provides a method for replacing the qualitative assessment of the many variables inherent in the vocational and technical education system with a quantitative method of evaluation. This permits the use of many quantitative techniques, which have been proven valid for industrial applications by industrial engineers, to be applied to the vocational and technical education system. The linear programming algorithm was demonstrated as being applicable for determining the optimal enrollment size. The control chart concept was shown to be applicable for use in evaluating the system state by monitoring and analyzing the dropout variable.

The first chapter presented a chronological history of the federal legislation and occupational changes which created new challenges to the administrators of the vocational and technical education system. The evaluation methods being used at the time of this study were analyzed and found to be inadequate for effective system planning. A strategy for economic growth, the need for statewide manpower planning and the objective of vocational and technical education were presented. In Chapter II, the factors related to development of a decision model were presented. The system functions, activities, and variables were generally described. Chapter III related to the development of mathematical expressions which describe the system. The mathematical expressions allow the use of proven quantitative techniques for making decisions. Chapter IV demonstrated the use of two quantitative techniques presently used in the industrial system decision process. The linear programming algorithm and the control chart concept were the two quantitative methods presented.

Conclusions

The research established procedures for the development of a decision model which adequately describes the vocational and technical education system. The model is acceptable to many agencies which comprise the vocational and technical education system. This was demonstrated by the action of the Occupational Training Information System (OTIS) staff to extract portions from this dissertation for inclusion in the Cycle Two Report -- A Second Yearly Report Complete With System Documentation, January 31, 1970 which was co-sponsored by the Oklahoma State Department of Vocational Education, the Manpower Administration, United States Department of Labor and others. Extracts taken from the dissertation, relating to the model, were also used as a segment of a graduate course presently being offered in the School of Occupational and Adult Education at Oklahoma State University.

The model developed is within the resource capability of the state since it is simply a manpower accounting procedure. It requires no elaborate data collecting procedures. A simple reporting procedure for the data is all that is required. The activities related to the system were determined and arranged in a sequential manner, thereby providing for ease in analysis. The variables describing the model were identified and their interrelationships were clearly defined. The variables can be quantitatively determined with a degree of accuracy that should increase the probability of producing more effective decisions related to vocational and technical education. The model was shown to be adaptable to two quantitative techniques extensively used by industrial engineers for evaluating industrial systems.

Proposals for Future Research

The following proposals for future research would affect the effectiveness of the vocational and technical education decision process:

1. An analysis of the degree of match between manpower demand and manpower supply which would contribute most to statewide economic growth.
2. An investigation of the parameters which should be optimized when considering changes for the vocational and technical education enrollment mix.
3. An analysis of the vocational education training programs to determine the programs which have a constant or a varying mean dropout rate.

The use of quantitative evaluation techniques on a total system basis for the vocational and technical education complex is relatively new. The concepts presented in this dissertation may make possible an application of other industrial engineering techniques which would assist the vocational and technical education manager in the decision process.

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APPENDIX A

TWELVE COMPONENTS OF A COMPREHENSIVE GUIDANCE SYSTEM FOR VOCATIONAL AND TECHNICAL EDUCATION

A Comprehensive guidance system must contain the 12 components listed below (28):

1. Orientation-in.

   Goal: for each student to acquire the various kinds of information, understandings, overt behaviors, and attitudes they need in order to function successfully both in a new educational system and in the specific school setting in which that system operates.

2. Personal assessment.

   Goal: for each student to know and understand the status of his development with respect to abilities, interests, physical and social characteristics and values in the areas of education, vocations, social behaviors, citizenship, learning behaviors, and use of leisure time.

3. Personal choice opportunities.

   Goal: for each student to know and understand the variety of opportunities available for personal involvement. The six areas for consideration encompass vocational, educational, citizenship, leisure-cultural-recreational, learning, and social opportunities.

4. <u>Personal problem solving skills</u>.

Goal: for each student to develop and use skills which enable him to solve problems by making decisions and plans wisely and implementing these.

5. <u>Personal problem solving</u>.

Goal: for each student to make and implement personal decisions and plans by integrating the knowledge and skills achieved in guidance components 1 through 4. Important here are experiences which enable students to formulate their goals and their plans for meeting these goals. Students must be aided to relate the instructional objectives in their programs of studies to their long-range goals. As students manage their performance toward these immediate and long-range goals, the continuous progress characteristic of individualized education is attained.

6. <u>Prescribed learning experiences</u>.

Goal: for each student to have assistance to resolve specific learning, intrapersonal, and interpersonal problems which are impeding his or her current progress and development. The number of such learning experiences is manifold. Examples are activities for behavior assessment and modification as well as for providing information on specific jobs, schools, courses, etc.

7. <u>Orientation-out</u>.

Goal: for each student to acquire the various kinds of information, understandings, overt behaviors, and attitudes they need in order to function effectively when they exit from an educational system or a specific school setting. Student needs here will vary, dependent upon what they anticipate doing after they terminate--e.g., entering the world of work, attending an institution of higher education, dropping out without specific plans, having a family, enlisting in the military.

8. <u>Monitoring and possible modification of aspects of the educational system</u>.

   Goal: to provide assistance from adults and technology so that each student in that system will be able to formulate and to progress toward agreed-upon goals.

9. <u>Monitoring and possible modification of school personnel</u>.

   Goal: to provide assistance from adults and technology so that communication with, and possible in-service training of, school personnel will be maintained so that each student will be able to formulate and to progress toward agreed-upon goals.

10. <u>Monitoring and possible modification of home and neighborhood factors</u>.

    Goal: to provide assistance from adults and technology so that communication with, and possible learning activities for, parents will be maintained so that each student will be able to formulate and to progress toward agreed-upon goals.

11. <u>Monitoring and possible modification of community resources</u>.

    Goal: to communicate with community representatives (e.g., health, social, and welfare agencies; businesses and industries) so that each student will be able to formulate and to progress toward agreed-upon goals.

12. <u>Research and evaluation</u>.

    Goal: to conduct experimentally-controlled studies for the evaluation of guidance and counseling techniques and procedures, follow-up studies of graduates and dropouts, analyses of changes in the characteristics of the student body so that each student will be provided with up-to-date, evidence-supported information and assistance.

APPENDIX B

OCCUPATIONAL TRAINING INFORMATION SYSTEM

ADVISORY COMMITTEE MEMBERS

Otis Advisory Committee (2)

Organization	Delegate	Alternate
U. S. Department of Labor Office of Manpower Research	Howard Rosen Director	Joe Epstein Chief, Econ. Dev. & Manpower Res. & Resources Group
State Department of Vocational and Technical Education	Francis Tuttle Director	Gordon Pulliam Coordinator of Indus. Services
Industrial Development and Park Department	R. Hunter Kemmett Act. Dir.	Carl Prier Fed. Programs Officer
Research Foundation Oklahoma State University	Marvin T. Edmison Asst. Vice. Pres. and Director	Howard Jarrell Assoc. Dir.
Oklahoma State Employment Security Commission	Morris Leonard State Dir. of Adm.	Will Bowman Chief, Research & Planning
Oklahoma School of Banking and Business (Private Schools)	Noel Adams President	Harold Fisher Pres., Hill's Business Univ.
Manpower Research and Training Center Oklahoma State University	John Shearer Director	David Stevens Assoc. Prof., Economics

Otis Advisory Committee

Organization	Delegate	Alternate
Governor of Oklahoma, Office of	Dewey F. Bartlett Governor	Jim Trickett Special Ass't. Indus. Devel.
North American-Rockwell Corp. (Oklahoma Industry)	Joe Robinson Director of Bus. Development	
Oklahoma Area Vocational and Technical Schools	Dale Hughey State Coordinator	Les Miller Ass't. State Coordinator
Tulsa Chamber of Commerce	Paul Lehman Mgr. of Local Development	
Oklahoma City Chamber of Commerce	Paul Strasbaugh Managing Dir.	Jack Byler Corp. Sec.
State Department of Vocational and Technical Education, Special Services Section	Arch Alexander Ass't. State Director	Hugh Lacy State Supv. MDTA
Oklahoma Council on Health Manpower	Thomas Points Univ. of Okla. Med. Center	Kenneth Hager Exec. Dir., Okla. Council for Health Careers
Central Oklahoma Economic District	Earl Price Director	Howard Vincent Health Planner
Ozarks Regional Commission	John Opitz Exec. Dir.	
Research Coordinating Unit Oklahoma Sate University	William Stevenson Director	William D. Frazier Assoc. Dir.
Department of Technical Education, Oklahoma State University	Donald Phillips Head	Lloyd Briggs Ass't. Prof.

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Education: Attended high school in Old Forge, Pennsylvania and graduated in 1947. Entered the United States Naval Academy at Annapolis, Maryland, in 1951; received the Bachelor of Science degree in General Engineering in 1955. Entered Oklahoma State University in Stillwater, Oklahoma in 1961; received the Master of Science degree in Mechanical Engineering in 1963. Completed the requirements for the Degree of Doctor of Philosophy in May, 1970.

Professional Experience: Served in the U. S. Air Force from June, 1955 to the present. Served as an Aircrew Member in the Military Airlift Command from November, 1956 to September, 1961. Served as a Project Engineer in the Air Force System Command from May, 1963 to June, 1965. Served as a Staff Development Engineer in the Air Force System Command from June, 1965 to May, 1967.