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ABSTRACT

This monograph is concerned with the uses to which an individualized student information system could be put for obtaining valuable insights into the progress of a variety of students through the educational system. In chapter 1, the concepts and terminology required for an understanding of transition matrixes are introduced, and a mathematical derivation of the basic flow equations and their matrix formulations is provided. Chapter 2 contains a numerical example of the applications of empirical transition matrix methods to the flows within two Ontario colleges of applied arts and technology, and chapter 3 discusses the benefits, limitations, and possible extensions of the method. (Author/RA)

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EMPIRICAL TRANSITION MATRICES

G.S. Tracz and J.T. O'Mahony

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PREFACE

This monograph was prepared as part of a report entitled Technology, Education, and Employment--A Study of Interactions--Part II--A Micro-Model of the Production and Use of Technicians. That report was carried out by the Department of Educational Planning of The Ontario Institute for Studies in Education during 1969-71, and it was submitted to the Canada Department of Manpower and Immigration and the Ontario Department of Education in June, 1971. The research was financed through a joint grant from these Departments under the Schedule 10 provisions of the Federal-Provincial Manpower Research Agreement of 1967. The authors wish to thank the Honourable William G. Davis, formerly Minister of Education for Ontario, for making that study possible.

The complete report is a study of the education and employment of engineering technicians and technologists, and other students in the technology programs in the Colleges of Applied Arts and Technology in Ontario. The report is divided into the following three parts which have been issued as separate Occasional Papers of the Department of Educational Planning:

Part I: The Education and Employment Survey of the Membership of the Ontario Association of Certified Engineering Technicians and Technologists.
Occasional Paper No. 4-71; by G.S. Tracz, M.L. Skolnik and J.T. O'Mahony.

Part II: Some Economic Aspects of the Relationship between Education and Employment of Technicians and Technologists in Ontario.
Occasional Paper No. 5-71; by M.L. Skolnik and G. Bryce.

Part III: Empirical Transition Matrices.
Occasional Paper No. 6-71; by G.S. Tracz and J.T. O'Mahony.

The references in this monograph to Part II pertain to the Department Occasional Paper No. 5-71 noted above.

The data upon which this study is based would not have been available but for the cooperation and assistance provided by Mr. Colin Wilson of the Ontario Association of Certified Engineering Technicians and Technologists, and and by the members of that Association.

The aesthetic neatness of the monograph came about largely in spite of the principal authors and must be attributed to the keen eye of Miss Ruth Sims of the OISE Editorial Division, the elegant drawing of Mrs. Helen Braithwaite, and especially to the painstaking typing and proofreading by Mrs. Lorraine Ratnik.

The principal authors owe a real debt of gratitude to Dr. Cicely Watson for helping to develop the idea for a study of this kind, providing periodic encouragement, and pushing numerous obstacles of of the way. Finally attention must be called to the fine work of Mr. J. T. O'Mahony in carrying out a substantial amount of the quantitative analysis, in addition to doing some of the writing.

INTRODUCTION

The administrators and decision-makers operating within the field of education have hitherto been concerned, in the main, with the static aspects of the institutions and educational processes for which they are responsible. This has led to the compilation of "stock" data about enrollment in various branches and levels of their particular educational jurisdiction. Useful as this information is for the immediately expedient purposes of the overall resource requirements of "the system," particularly financial, it gives little insight into the important dynamic features, and is clearly unsuitable for monitoring internal changes and trends and for making informed decisions about future developments.

For these reasons and others, many interested parties have been advocating the establishment of some form of individualized student information system (1).

This report is concerned with the uses to which such an information base could be put by constructing and analyzing empirical transition matrices and showing their relevance to monitoring and decision-making in educational environments such as the CAATs.

One such analysis has been undertaken by W. P. McReynolds (2) for the Ontario secondary school system using the comprehensive individualized data contained in (3). Although restricted to the time period 1959-64, this study did establish the feasibility of applying transition matrix methods to secondary school educational systems and their usefulness in obtaining valuable insights into the progress of various types of students through the system. The study also demonstrated the feasibility of using the estimated transition matrices for the simulation of enrollments by grade and branch.

Chapter 1 provides an introduction to the concepts and terminology required for an understanding of the subsequent development. Some simple examples are given to consolidate these ideas. In addition, a subsection is devoted to a mathematical derivation of the basic flow equations and their matrix formulations.

Chapter 2 contains a numerical example of the application of empirical transition matrix methods to the flows within two Colleges of Applied Arts and Technology.

Chapter 3 discusses the benefits, limitations, and possible extensions of the method.

CHAPTER 1: THEORETICAL DEVELOPMENT

1 - 1. Introduction of Concepts and Terminology

The term "system" occurs in a variety of contexts and with a wide range of meanings. Dictionary definitions usually refer to a number of interrelated elements, items, or components operating together to serve a single function. Physical and biological systems such as a spacecraft system, the nervous system, an electrical system, a transportation system, or a hydro system, appear to comply with this definition.

However, many other uses of "system" elude interpretation in the above manner. Some uses, for instance, seem to denote the ways, means, and rules of procedure for doing something, such as a bidding system, a coordinate system, an examination system. Yet another usage seems to refer simply to a complex of elements with no well-defined function, such as stellar systems.

The greatest deviation in meaning occurs in the social sciences with terms such as the social system and the educational system, whose elements are presumably individual human beings not apparently serving any single function. If they were, what could it be?

The confusion demonstrated above lies in the attempt to visualize systems as physical entities rather than conceptual organizations of certain experiences. The common function is that of utility, of imposing a conceptual structure upon sometimes complex phenomena in order to make necessary decisions. The system, then, will depend upon the perspective of its designer and the uses to which it might be put.

The dictionary definition itself is misleading, since clearly it is not the elements which are interrelated but the properties of these elements. In other words, if nothing is known about a set of elements, nothing predicated upon them, then relationships are meaningless.

In this report we shall be concerned mainly with conceptualizations of educational phenomena largely from the perspective of those with the responsibilities for administration, resource allocation, program management, and policy-making, operating in educational environments such as secondary schools, universities, and Colleges of Applied Arts and Technology.

In general terms then a <u>system</u> comprises a set of distinct elements (content), the properties of these elements, and the relationships between such properties (properties of properties).

The necessity for "systematizing" the experiences and observations of such complex phenomena as characterize education derives from the need to reduce these phenomena to manageable proportions and moreover to a form suitable for logical inferences, in order to make and communicate rational decisions. The objectives and resources of the particular decision-maker involved will determine:

(a) the elements of the system, i.e., the content;

(b) the relevant properties of these elements, i.e., the degree of detail;

(c) the admissible relationships holding between properties, i.e., structural complexity of system.

Applying these concepts of "system" to some area of educational experience, such as secondary school, or the entire phenomena of formal education and employment, it becomes clear that what education is about--that is, its content, its students and/or teachers and/or administrators, giving parallel systems. If we restrict the discussion for the moment to a "student system" (where the elements considered are students), what can be stated about their properties? Clearly each student has a multitude of properties, most of which can be considered to be irrelevant to the objectives of the planners or decision-makers (color of hair, height, etc.).

However, such decision-makers will most probably want to know something about the distribution of students among the various levels, grades, and branches within their jurisdiction, in order to allocate financial and teacher resources effectively and to evaluate the progress of any student or students through these levels. Clearly the property of "being in a particular educational level" can be operationally defined--by enrollment procedures, academic qualification requirements, and so forth, during some convenient period of time, usually the school year for elementary and secondary school education or perhaps one semester for university education.

The choices of these transient locational properties, or "states" as they will subsequently be called, are primarily determined by the interests of the planner or administrator who is required to make decisions as to specific educational needs and the allocation of resources, insofar as he is able to isolate qualitative similarities of educational experience or qualifications amongst groups of students. For example, in a secondary school system, under existing arrangements in Ontario, the grade and program would usually suffice to define an educational "state." However, it is important to retain the generalized notion of a "state" when alternative structures in education are envisioned. The introduction of a credit achievement method in high schools would involve radically new operational definitions for setting up the educational states of the system.

The possible states of the system are by no means the only properties of students which are worthy of consideration, although they might well suffice for many accounting and budgeting applications. Certain permanent properties (characteristics) of students such as their sex, socioeconomic background, or geographical origin may be of considerable use in mathematical models based on the system as predictors of academic achievement and other educational behavior, or where questions of equality of opportunity need answering. Since such properties do not change with time, they effectively partition the systems' elements (students) into what can be called <u>population classes</u>, which in most subsystems can be treated independently of one another. However, where constraints apply to the total population of any state or states in the system, the interaction of population classes <u>must</u> be taken into account, as McReynolds (2) has demonstrated in the case of postsecondary transitions.

To complete a systems definition, the logical relational properties of the states and those of the population classes, referred to above, must be well defined. Mathematical models of systems, relying as they do on the counting (unambiguously) of the numbers of elements with specified properties, will normally require that the properties be <u>mutually exclusive</u>: that is, each student (say) must be in only one state and population class at any given time. Furthermore, since it is desirable to keep track of all individuals considered to be in the system, each student must be in one of the possible states or classes. To effect this requirement of <u>exhaustiveness</u> of properties may necessitate the setting up of an artificial "state" which is complementary to all the other states of the system. Thus when an individual meets none of the operational specifications of the other states he is assigned to this residual state. Such a state (or states) might, for example, cover the cases of students who drop out of school, join the labor force, emigrate, or for some reason are not included in the mainstream of the educational process being systematized.

The other necessary relations which contribute to the logical structure of a system will usually be supplied by educational policies, rules, laws, and conventions, extant within tho pertinent educational environment. A case in point would be the relationship between a state, defined as grade 12 of a five-year program completed, and its valid successor states: grade 13 of the same program, first year of a 2-year program at a College of Applied Arts and Technology, first year of a 3-year program at a College of Applied Arts and Technology, the labor force, repetition of grade 12, and so on. Clearly the admission policies of the Colleges of Applied Arts and Technology, and the promotion policies of secondary school authorities concerning the 5-year program, determine some of the possible relations between these states. The successor relationship between states, as illustrated above, will occupy our attention exclusively for the remainder of this report, since we will be interested predominantly in the dynamics of students' educational progression.

The pictorial analogue of this logical structure is the flow chart, which schematically represents both the states of the system and the valid successor relationships between them. The states of the system are conventionally represented by labeled boxes and their interrelationships by directed lines connecting valid successor and predecessor states. The example given above might then appear as in figure 1.

Figure 1. System Flow Chart Example

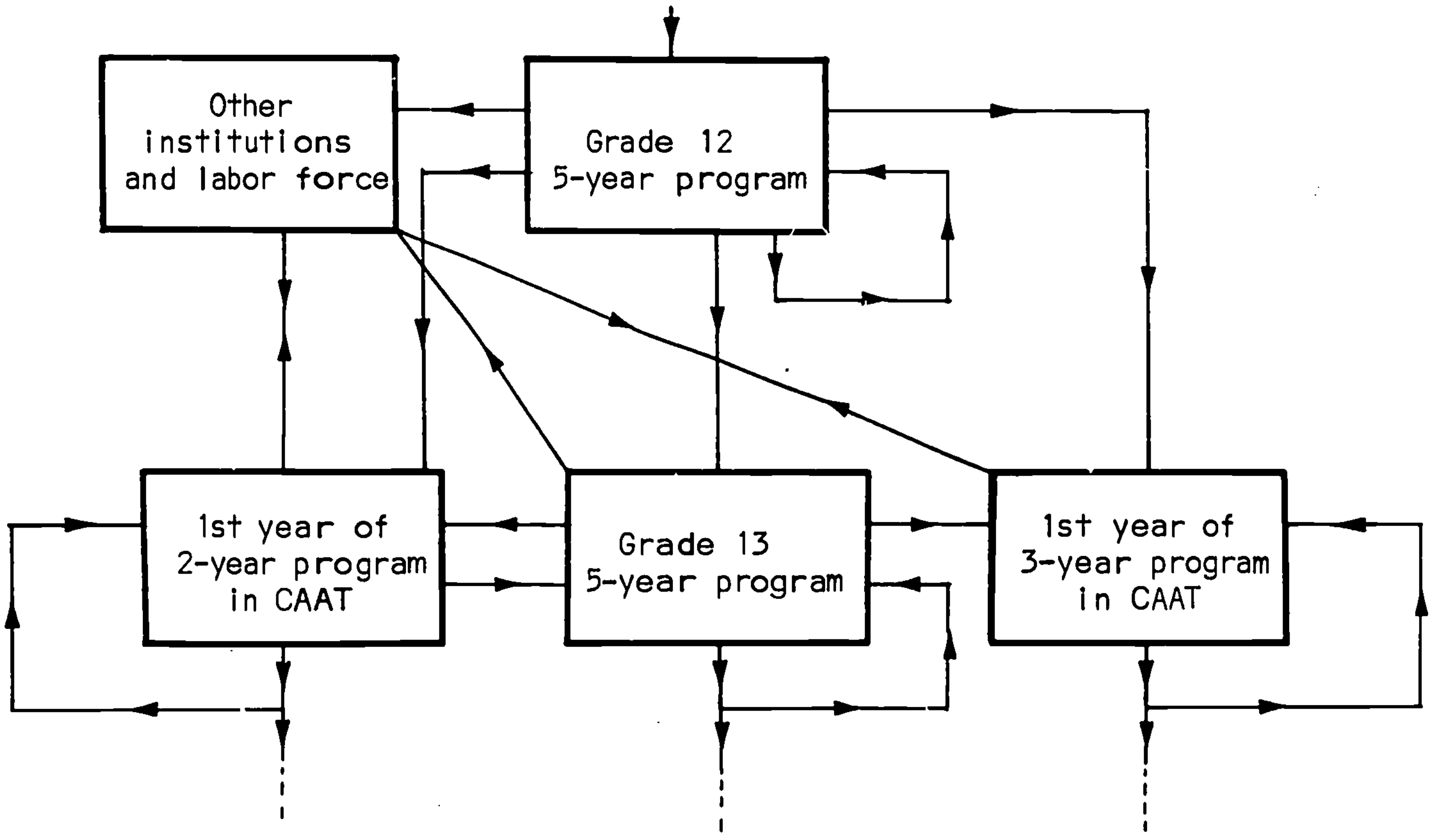

Table 1. System Tabular Representation Example

	Grade 12 (5-yr. prog.)	Grade 13 (5-yr. prog.)	1st yr. of 2-yr. prog. (CAAT)	1st yr. of 3-yr. prog. (CAAT)	Other institutions & labor force
Grade 12 (5-yr. prog.)	1	1	1	1	1
Grade 13 (5-yr. prog.)	0	1	1	1	1
1st yr. of 2-yr. prog. (CAAT)	0	1	1	1	1
1st yr. of 3-yr. prog. (CAAT)	0	0	1	1	1
Other institutions & labor force	0	1	1	1	1

The flow-chart representation for such systems usually provides considerably more intuitive insight and conciseness into the structure of a system than would some symbolic logical representation. It also suggests the use of such terms as flow and transition because of the apparent "movement" of students, year by year, from one state to another along the directed lines.

Clearly, unique quantities can be associated with both the boxes (states) and the directed lines (interstate relationships) at any time. The quantity associated with a state could be defined as the number of students observed in that state during a given time period, and will be called the stock of that state. Similarly the number of students observed as changing their state at the end of the time period will be called the flow between the two states concerned.

An alternative portrayal of the logical structure of a system is that of tabular representation. A table (or matrix) is constructed with both the rows and columns labeled with the names of all states of the system. The entries in the table are then indicated by 1s or 0s according to the possibility of a direct transition between them in the systems: that is, a 1 would correspond to a line on the flow chart. The example given above would be represented by table 1.

The row states of such a table are usually referred to as origin states and the column states as destination states.

This representation clearly contains more redundant information about the system than does the flow chart. Nevertheless, because of its symmetry and matrix formulation, it is in general mathematically more tractable, as will be demonstrated in Chapter 2.

Again, as for the flow chart, numbers may be associated with the non-zero entries in such a table, the row sums of these corresponding to "stocks" and individual entries to "flows." The resulting table is called a flow matrix.

The foregoing discussion may appear to be overly fastidious and pedantic to those faced with day-to-day decisions in education. However, its main import is to stress the concept of system as a logical construct, an abstraction, which if properly designed can lead to meaningful insights and mathematical formulations of educational phenomena, and hopefully to avoiding the pitfalls awaiting the misapplication of quantitative techniques in this area.

1 - 2. Mathematical Formulation

In the brief discussion that follows, the mathematical notation adopted is that of McReynolds as used in The Ontario Educational System (2). Included are the definitions and basic equations that describe the stocks and flows within the conceptualized system introduced in 1 - 1. Again it is assumed that a suitable set of mutually exclusive and exhaustive states has been defined and, if necessary, a similarly constrained set of population classes. The elements (or subjects) considered in the system might be students, teachers, or some other educationally relevant population, depending upon the purposes of the analysis. Also the system states included might only account for a limited amount of the educational history of a student. As such it would constitute a subsystem of a "total" educational system which perhaps might cover the whole of a student's formal education and employment history. Such subsystems should ideally be single administrative entities which are internally isolated from other sybsystems. If important exogenous connections do in fact exist (as is often the case), the inputs concerned are unpredictable to any model of the subsystem. Examples of subsystems might be individual educational institutions such as universities or CAATs, the whole of postsecondary education, the whole of elementary school education, and so on.

Let a particular state of the system be denoted by the symbol r, where r is an integer taking some value between 1 and R (the total number of states in the system).

Let the stock of subjects in state r at time t be represented by n(r;t); then the total number of subjects in the system, N(t), at some time t must be given by:

$$(1) \qquad N(t) = \sum_{r=1}^{R} n(r;t)$$

If the subjects have been partitioned into A distinct population classes, according to their supposed educationally relevant permanent characteristics, then an additional index, a, would be required to indicate which class is being considered.

Then n(a;r;t) is defined to be the number of subjects who are members of population class a, and counted in state r at time t.

The following equations then ensue:

$$(2) \qquad n(r;t) = \sum_{a=1}^{A} n(a;r;t) \qquad r = 1, 2, \ldots, R$$

$$(3) \qquad N(t) = \sum_{r=1}^{R} \sum_{a=1}^{A} n(a;r;t)$$

The flow of members of class a from origin state r to destination state s, as observed at the end of time period t, is denoted by f(a;r,s;t). Since all subjects initially considered in the system must remain within it at subsequent time intervals, even if they are counted in some artificial or terminal state, the sum of the flows originating in state r (including repeaters) must equal the stock of state r. This is expressed by:

$$(4) \qquad n(a;r;t) = \sum_{s=1}^{R} f(a;r,s;t) \qquad r = 1, 2, \ldots, R$$

As illustrated in table 1, a table can now be constructed in which the entry in row r and column s is given by f(a;r,s;t). The numbers in the table are determined by those individuals observed to be in state r at time t and also in state s at time t+1. The row sums are given by equation (4) above.

A separate table could be constructed for each population class in the system. Similarly tables can be compiled for each year t for which flow observations are available. They cannot, however, be usefully compared, with respect to changes in flow patterns, until normalization has taken place.

Therefore we define:

$$p(a;r,s;t) = \frac{f(a;r,s;t)}{n(a;r;t)} \qquad \begin{array}{l}\text{For any}\\ r = 1, 2, \ldots, R\\ s = 1, 2, \ldots, R\\ a = 1, 2, \ldots, A\end{array} \tag{5}$$

where from (4)

$$\sum_{s=1}^{R} p(a;r,s;t) = 1 \qquad r = 1, 2, \ldots, R \tag{6}$$

These p(a;r,s;t) are known as <u>transition proportions</u>, and the table in which they occur as entries in the r-th column and s-th row is known as a <u>transition matrix</u>. The transition proportions may be interpreted as the proportion of subjects of class a, observed to be in state r at time t and also in state s at time t+1. For example if r were grade 9 secondary school and s were grade 10 secondary school and t was 1960, with class a representing male students, then p(male; grade 9, grade 10; 1960) and p(male; grade 9, grade 9; 1960) would be the promotion and repetition proportions respectively for grade 9 male students at the end of the 1960 academic year.

If, in fact, new subjects can enter a state from outside the system, a further quantity u(a;r;t) must be introduced in order to arrive at the correct stocks for each state, and u(a;r;t) is interpreted as the new entrants to the state r from outside the system, of population class a, during time period t. Thus these new entrants, if any, into the states of the system, added to the flows of the previous year from within the system, give the current stocks in each state.

The basic flow equations become:

$$(7)\quad n(a;s;t+1) = \sum_{r=1}^{R} f(a;r,s;t) + u(a;s;t+1) \qquad s = 1, \ldots, R$$

or from (5)

$$(8)\quad n(a;s;t+1) = \sum_{r=1}^{R} n(a;r;t)*p(a;r,s;t) + u(a;s;t+1) \text{ for } s = 1, 2, \ldots, R$$

The R equations of (8) above may be expressed more concisely in the standard matrix notation below:

$$(9)\quad \underline{n}_a(t+1) = \underline{n}_a(t)*\underline{P}_a(t) + \underline{u}_a(t+1)$$

where $\underline{n}_a(t)$, $\underline{u}_a(t)$ are the row vectors given by

$$(10)\quad \underline{n}_a(t) \equiv \left| n(a;1;t), n(a;2;t), \ldots, n(a;R;t) \right|$$

$$\underline{u}_a(t) \equiv \left| u(a;1;t), u(a;2;t), \ldots, u(a;R;t) \right|$$

and the transition proportion matrix $\underline{P}_a(t)$ is given by:

$$(11)\quad \underline{P}_a(t) \equiv \begin{vmatrix} p(a;1,1;t) & p(a;1,2;t) & \ldots & p(a;1,R;t) \\ p(a;2,1;t) & p(a;2,2;t) & \ldots & \\ \cdot & & & \\ \cdot & & & \\ \cdot & & & \\ p(a;R,1;t) & \ldots & \ldots & p(a;R,R;t) \end{vmatrix}$$

For a given value of t, and when the stocks in time periods t and t+1, flows at the end of time period t, and new inputs in time period t+1 are all known, equation (9) becomes simply an empirical identity. Such a formulation is in itself a useful exercise in monitoring changes in transition proportions over time.

However, if certain assumptions are made about the transition matrix $\underline{P}_a(t)$, equation (9) provides a method of projecting future stocks $\underline{n}_a(t+1)$, $\underline{n}_a(t+2)$, and so on, from the latest known stocks $n_a(t)$, by repeated application of this equation. Such a procedure, of course, requires independent projections of new inputs $\underline{u}_a(t+1)$, $\underline{u}_a(t+2)$, etc., for a complete simulation model of future enrollments.

The first assumptions which must be made are those of the classical deterministic Markov process: namely,

(a) one-step dependency--i.e., everyone in state r at time period t is subject to the same transition behavior regardless of how he arrived in that state. State membership during earlier periods does not affect an individual's transition at the end of time period t.

This assumption cannot always be justified; for example, those students in secondary school who have repeated one or more earlier grades might well tend to drop out of school in proportionately greater numbers than those who have experienced regular promotions. Thus, the dropout transition proportion would vary with the proportion of the grade enrollment having one or more earlier grade repetitions. However, such multistage dependencies may often be neglected when their occurrence is relatively rare as compared to the great majority of transitions made. In addition there are

(b) unconstrained flows--i.e., there are no numerical bounds on the number of people either leaving or entering a particular state. In other words, the transition proportions are meaningful abstractions of transition behavior and not contingent upon the vagaries of fluctuating enrollments.

Some further assumptions must also be made about future transition behavior, the ways in which transition proportions will change over time. If no pertinent changes in educational policy or practice are anticipated during the period of projection, then it might reasonably be expected that the transition proportions would remain relatively stable. In this case, the simplifying hypothesis of a stationary transition proportion matrix could be adopted: that is to say, $\underline{P_a}(t)$ is independent of time. (Thus, $\underline{P_a}(t)$ becomes simply $\underline{P_a}$.)

Successive application of the matrix recurrence relationship (9), designating $\underline{n_a}(o)$ as $\underline{u_a}(o)$ and adopting the convention $\underline{P_a^o} \equiv I$ (the identity matrix), leads to the following projected stocks in the system after T time periods have elapsed from the base year t=0.

$$(12) \quad \underline{n_a}(T) = \sum_{t=o}^{T} \underline{u_a}(t) * \underline{P_a}^{T-t}$$

Although the stationary hypothesis leads to elegant results, such as (12), it is rarely justified over lengthy time periods. However, if the causal mechanism by which transition proportions are produced is even partially understood, the enrollment implications of a variety of educational policies and trends may be calculated from equation (9) by judiciously varying the successive transition matrices $\underline{P_a}(o)$, $\underline{P_a}(1)$, etc.

CHAPTER 2: A NUMERICAL EXAMPLE

2 - 1. Discussion of the Data

This chapter will be devoted to the illustration of the concepts and techniques developed in the first chapter. The subjects to be considered were technical and technology course students enrolled in two Ontario Colleges of Applied Arts and Technology.

A study was made of those students who entered these colleges in the academic years 1967/1968 and 1968/1969. The information sought from each student was as follows:

1. The program of education at the college.
2. Year of birth.
3. High school percentage.
4. Geographical area of high school last attended.
5. High school program (4-year, 5-year, or other).
6. High school course type (Arts and Science; Business and Commerce; Science, Technology, and Trades).
7. Occupation of father.
8. First-year results at college (passed, withdrew, or failed).
9. Second-year results at college (passed, withdrew, or failed).

There were three possible programs available to these students: technical assistant (1 year), technical (2 years), and technology (3 years).

The Technical assistant program was only provided at one of the two colleges. We can therefore define six states for students of one college and five for students of the other college, corresponding to the programs and year of study. The stocks for these states are derived from the information made available from item 1. Items 1, 8, and 9 provide sufficient information for the determination of the flows. Items 2 through 7 can be considered as permanent characteristics as far as the college systems under discussion are concerned and enable us to partition the students into population classes for the analysis of possible differences in progression through the colleges.

The flow tables and transition proportion matrices which follow have been compiled to illustrate flows within the college and into the labor force. The latter destination state has been further subdivided by the academic status of the students entering it--having passed, failed, or withdrawn from the course.

Before embarking upon the analysis, however, some points must be made as to the adequacy and precision of the available data.

The data obtained from one of the two colleges proved to be far from ideal material for the construction of flow and transition matrices. This was mainly owing to the fact that only the first-year results of the new entrants in the 1967/68 academic year were obtained. Thus no complete program cycle could be observed. Furthermore, the information available concerning reasons for withdrawal from a course and the destinations of those who transferred to another course were in general omitted.

A somewhat fuller picture emerges from the data of the other college, although even here the longest program cycle (for the technologists) is incomplete. This, however, was unavoidable, since the college had been functioning for only two years.

Some general deficiencies for the purposes in hand, apparent in the material obtained from both colleges, were as follows:

(a) Enrollments were small at this stage in the development of the colleges, and this created difficulties in the interpretation and comparison of transition proportions.

(b) Clearly in the first two years of such novel institutions a considerable amount of experimentation with course structures, admission policies, and academic standards is inevitable, and stable transition proportions could not be expected.

(c) There are some small discrepancies between the total number of enrollments derived from this data source and the corresponding figures published by the colleges. Also the distribution of students by programs and courses is not always in agreement. A possible source of such discrepancies could be the date of publication of college enrollment statistics (early in the academic year) and the subsequent corrections made to student records as a result of late entries or internal transfers (perhaps to outside the technical division).

(d) Although high school program or course and percentage grade obtained are given for the majority of students enrolled, the basis for admission is rarely made explicit. It is not clear, therefore, whether a student was admitted as a mature student, as a manpower retrainee, or on the basis of high school performance. Also the year of graduation from high school is omitted.

(e) Item 7, father's occupation, is frequently inadequate for classification into well-defined occupational categories and hence a certain amount of guesswork had to be employed in the construction of population classes based upon this characteristic.

The analysis which follows will largely be concerned with student records from the one college for which the data are more or less complete over a two-year period.

First, the new enrollments into the college for the academic years 1967/68 and 1968/69 are broken down by some of the background characteristics of students which might be considered as pertinent to a student's performance and aspirations in higher education.

The technicians in tables 2 and 3 have been subdivided by courses--mechanical, electrical, electronic, construction, and industrial technicians--to identify any variations in background characteristics between course enrollments. It should be borne in mind when consulting these two tables that some students' records had one or more data items missing, and consequently the total enrollments in a program or course may differ from one background characteristic to another. The actual total enrollments by program type will be found in the far right columns of tables 6 and 7, and those for technician courses in table 10:

A few comments are necessary at this point to specify the operational definitions which have been used to categorize background characteristics. Thus, in the order of appearance in table 2:

1. Age at entry was simply calculated by subtracting year of birth from year of entry into the college. The age categories selected are meant to give some indication as to the amount of delay experienced by new entrants either during school or after leaving high school. (The effectiveness of this categorization is greatly reduced by the absence of a "year left high school" data item.) For example, the 17-18 age group can be assumed to have just left high school, whereas

the 19-year-old group will generally have had some delay, such as repeating one grade in school, working for a year, or attending some other postsecondary institution after high school.

2. <u>High school average</u> is included in order to attempt to relate high school academic performance to progress in the CAAT, and the five-percentage-point intervals represent a reasonable balance between the competing needs for both precision and aggregation for this size of population.
3. <u>The high school program and type</u> backgrounds of new entrants, indicating as they do the duration and emphasis of pre-CAAT schooling, might well influence the contents and prerequisites for college courses and to some extent explain premature withdrawals for reasons of lack of interest or difficulty encountered. However, the fact that a new entrant was included in a particular program category does not imply that he completed it.
4. <u>Father's occupation</u> categories have been defined with the aim of specifying the degree of formal training undergone by the father of a new entrant, to the extent that this could be assessed from the sometimes loose occupational descriptions in the student's records ("foreman," "superintendent"). Thus, "professional" occupations are those which would seem to require a university degree or its equivalent--doctor, chartered accountant, etc. The "skilled" category comprises occupations which would normally require some kind of formal technical training or apprenticeship leading to certification: laboratory technician, tool-and-dye maker, plumber. "Semi-skilled" denotes

occupations with skills acquired by experience on the job, with perhaps some company training: machinist, crane operator, etc.

The final category, "unskilled," is a residual category including deceased and retired fathers as well as unspecified occupations. It also includes occupations with minimal training requirements, such as truck driver, laborer, storeman. In addition, farmers are included in this occupational category since the economic region served by this particular college has only about 9% of its farms qualifying as viable farm units (with agricultural sales greater than $10,000 per annum).

It can be seen, on the basis of the definitions given above, that each characteristic has been subdivided into mutually exclusive and exhaustive categories which provide the means for partitioning total enrollments into population classes.

A few general remarks pertaining to the main characteristics of new entrants between 1967 and 1969 may be made with reference to tables 2 and 3. First, 44 out of 128 (almost 40%) students entering the technical division between 1967 and 1969 were 20 years of age or older. This compares with 80% for the college as a whole. The technologist branch appears to be somewhat older for both entry years, a probable consequence of the relatively larger proportion of 5-year program students who enroll in that branch. It will be noted also that although enrollment in 1968/69 is up by 31% over 1967/68, almost all of the increase is accounted for by students in the 19 and over age categories.

Table 2. New Entrants 1967/68

		Technologists	Technicians					
		No.	Mech.	Electric.	Electron.	Constr.	Indust.	Total No.
Age at Entry	≤ 17-18	1	7	2	3	0	4	16
	19	11	6	6	5	0	2	19
	20-21	12	2	0	3	0	3	8
	≥22	4	0	0	3	0	0	3
High School Average (%)	≤ 50-54	3	0	1	1	0	0	2
	55-59	5	4	2	4	0	1	11
	60-64	11	3	1	4	0	3	11
	65-69	2	3	2	3	0	2	10
	70+	4	4	2	1	0	3	10
High School Program & Course	4-yr. ST&T	6	12	6	8	0	8	34
	5-yr. ST&T	2	1	0	2	0	1	4
	4-yr. A&S	8	2	1	1	0	0	4
	5-yr. A&S	10	0	1	2	0	0	3
	Other or N.A.	2	0	0	1	0	0	1
Father's Occupation	Professional	2	0	0	1	0	0	1
	Skilled	5	3	0	3	0	1	7
	Semi-skilled	8	7	1	7	0	3	18
	Unskilled	13	5	7	3	0	5	20

Table 3. New Entrants 1968/69

		Technologists	Technicians					
		No.	Mech.	Electric.	Electron.	Constr.	Indust.	Total No.
Age at Entry	≤ 17-18	3	0	2	1	8	7	18
	19	5	5	8	7	6	5	31
	20-21	4	4	7	2	6	7	26
	≥22	3	4	0	2	1	0	7
High School Average (%)	≤ 50-54	1	2	2	0	0	1	5
	55-59	3	1	4	3	2	3	13
	60-64	5	5	7	7	8	6	33
	65-69	2	3	2	0	4	4	13
	70+	2	1	2	1	7	5	16
High School Program & Course	4-yr. ST&T	3	6	10	6	13	16	51
	5-yr. ST&T	1	0	3	3	0	0	6
	4-yr. A&S	4	6	4	1	7	3	21
	5-yr. A&S	5	0	0	1	1	0	2
	Other or N. A.	2	1	0	1	0	0	2
Father's Occupation	Professional	2	0	1	0	1	2	4
	Skilled	1	4	2	0	3	2	11
	Semi-skilled	7	5	5	4	7	7	28
	Unskilled	5	4	9	8	10	8	39

The distribution of high school average for technologists remains fairly stable for the two cohorts, with 26 out of 38 (68%) such students having averages of 60% or over. Among technicians, however, the proportion with 60% and over increases from 69% in 1967 to 78% in 1968, with the newly instituted construction course attracting relatively highly qualified students. A surprisingly large proportion (almost 20%) of all entrants achieved averages of 70% or more in high school. (Indeed, 41% of this group had averages over 75%.) The 4-year programs provided nearly all of these high-achieving students.

The distribution of students entering the technologist program, considering high school program and type, was essentially unaltered from 1967/68 to 1968/69; about 46% had come from a 5-year program (excluding other and N.A.) with 69% of these from the Arts and Science course types.

On the other hand the 1967/68 technician entry was predominantly (74%) from 4-year Science, Technology, and Trades programs, whereas in 1968/69, 4-year Arts and Science programs contributed significantly (26%) to the increased enrollment.

Tables 4 and 5 provide the breakdown of these program-and-type populations by high school averages for all new entrants. It appears from these tables that 20 students out of the 167 (12%) might have been sufficiently qualified upon leaving high school to have entered university (with 60% average marks or over, in a 5-year program).

Father's occupation does not appear to be a contributory factor in the choice of program at the college. It is interesting to note the proportion of farmers' sons who enrolled in the college's technical division, in view of the rural nature of this region as a whole. (In 1961, agricultural occupations in the labor force were twice as high as the provincial average,

Table 4. Technologists 1967/69

High School Program/type	High School Average (%)			
	50-59	60-69	70+	Total
4A&S	4	6	2	12
5A&S	7	7		14
4ST&T		4	4	8
5ST&T		2		2
Other	1	1		2

Table 5. Technicians 1967/69

High School Program/type	High School Average (%)			
	50-59	60-69	70+	Total
4A&S	9	6	9	24
5A&S	2	2	1	5
4ST&T	22	53	14	89
5ST&T	3	6	2	11
Other				

and represented 13% of the labor force.) In the two cohorts entering the technical division, about 12.5% of students in each year give their father's occupation as "farmer." This figure compares with 20% for the college as a whole.

Only two girls were enrolled in the technical division between 1967 and 1969, both of whom completed and passed the 1-year technical assistant's course.

2 - 2. Student Flows and Transition Proportions.

Tables 6 and 7 give student flows, aggregated by program type within the technical division, for periods 1967/68 and 1968/69 respectively. To illustrate the interpretation of these tables, consider the second row of table 6. The entries in this row show that there were 46 students enrolled in the first year of a technician's program (TN_1) in 1967/68, of whom 35 passed the year and enrolled in the second year of the same program (TN_2), 1 passed and withdrew (P), 8 withdrew during the year (W), and 2 failed the year and left the college (F). Clearly no student could graduate (GRAD) from the technician program after completing only the first year.

Since there were no enrollments in the second year of any technical program in the 1967/68 session at the college, table 6 only provides information about the flows between the first and second years of any program--$(CAAT)_1$ to $(CAAT)_2$. Table 7, however, allows for comparisons between the first- and second-year flows of these programs. Clearly, most of the withdrawals and failures take place in the first year of a program. In fact, in both the 1967/68 and 1968/69 sessions just over 25% of students

Table 6. Student Flow 1967/68 by Program Type in CAAT (All Students)

1967 ↓ → 1968

Level	CAAT Program*	(CAAT)$_1$			(CAAT)$_2$		(CAAT)$_3$	Labor Force or Other Ed.				Total Enrollment
		TA$_1$	TN$_1$	TLG$_1$	TN$_2$	TLG$_2$	TLG$_3$	P	W	F	GRAD.	
(CAAT)$_1$	TA$_1$				▨	▨	▨	▨			2	2
	TN$_1$				35	▨	▨	1	8	2	▨	46
	TLG$_1$					17	▨	2	9		▨	28
(CAAT)$_2$	TN$_2$		▨			▨	▨	▨				
	TLG$_2$			▨							▨	
(CAAT)$_3$	TLG$_3$					▨		▨				

	TA$_1$	TN$_1$	TLG$_1$	TN$_2$	TLG$_2$	TLG$_3$	Subtotals for Labor Force, etc.				1967/68 Enrollment
New Entrants		82	15								
Total Enrollment 1968/69		82	15	35	17		3	17	2	2	76

*CAAT programs: technical assistant (TA); technician (TN); technologist (TLG).
The interpretation of the abbreviations P, W, and F are as follows: P - failed a year of a program; W - withdrew from a program; and F - failed a year of a program.

Table 7. Student Flow 1968/69 by Program Type in CAAT

↓ 1968 → 1969

Level	CAAT Program	(CAAT)$_1$			(CAAT)$_2$		(CAAT)$_3$	Labor Force				Total Enrollment
		TA$_1$	TN$_1$	TLG$_1$	TN$_2$	TLG$_2$	TLG$_3$	P	W	F	GRAD	
(CAAT)$_1$	TA$_1$				▨	▨	▨	▨				
	TN$_1$				58	▨	▨	1	21	2	▨	82
	TLG$_1$					13	▨	▨	2		▨	15
(CAAT)$_2$	TN$_2$		▨			▨	▨				7* / 28	35
	TLG$_2$			▨			16		1		▨	17
New Entrants								Subtotals for Labor Force, etc.				1967/68 Enrollment
Total Enrollment 1968/69					58	13	16	1	24	2	35	149

*conditional

enrolled in the first year of a technicians' or technologists' program failed to complete the years' requirements (W or F), whereas only one student out of the 52 in the second year of the same programs in 1968/69 did not pass. (He was advised to withdraw). Of those who completed the 2-year technicians' program in 1969, however, 7 were given conditional graduate status, not having met all of the graduation requirements at that time. (The subject causing most delays seemed to be mathematics).

It is appropriate at this point to list the reasons (if any) given for withdrawal on students' records.

TECHNICAL DIVISION

Reasons for withdrawal	1967/68	1968/69	Total
1. Advised to withdraw	5	4	9
2. Low marks	0	7	7
3. Course too difficult	3	0	3
4. Not interested in course	1	1	2
5. Obtained employment	1	1	2
6. Returned to high school	0	1	1
7. Moved residence	1	0	1
8. Financial problems	0	2	2
No reason given	6	7	13
TOTALS	17	23	40

The first three reasons given in the list above are concerned with the academic standing of the students involved. These account for 70.4% of withdrawals for which some reason is provided. The remaining five reasons indicate responses to alternatives and pressures external to college performance. Background characteristics appear to be an unreliable guide for the prediction of these withdrawals even in the case of students who found the course too difficult. One of them, in fact, had graduated from a 4-year Arts and Science program in high school with a 77% average. (Only age seems to have relevance--7.5% are 17 or 18 years old.)

Although new entrants into technician and technologist programs increased from 74 in 1967 to 97 in 1968, the first-year technologist enrollment went down by almost half, whereas the first-year technician enrollment almost doubled. The effects of this adjustment may be seen in the transition proportion matrices of tables 8 and 9, where the pass rate for technologists increases by 26% (from 61% to 87%) in 1968/69. The spectrum of background characteristics of the new entrants, remaining as they do essentially unchanged, do not appear to explain this improvement and we might speculate that the smaller number of technologists in 1968/69 were more readily accommodated than those of 1967/68.

Table 10 provides the breakdown of first-year technician flows by course for the two entry years 1967 and 1968. In general there is a decrease from 1967/68 to 1968/69 in the proportion continuing into the second year of each course, with the exception of the Mechanical technicians' course, where the pass rate was very low in 1967/68. In fact, when the newly instituted Construction course is left out of the reckoning the overall retention of first-year technicians decreases from 76% in 1967/68 to 65.5% in 1968/69. From another perspective, even though the technician program expanded by 32.6% (excluding Construction) in 1968/69, the number of students continuing into the second year expanded by only 14.3%, and the number of withdrawals more than doubled.

Table 8. Transition Proportions 1967/68 Program Type in CAAT (All Students)

1967 ↓ → 1968		$(CAAT)_1$			$(CAAT)_2$		$(CAAT)_3$	Labor Force				Total Enroll-ment
Level	CAAT Program	TA_1	TN_1	TLG_1	TN_2	TLG_2	TLG_3	P	W	F	GRAD	
$(CAAT)_1$	TA_1				▨	▨	▨	▨			1.0	2
	TN_1				.76	▨	▨	.02	.17	.04	▨	46
	TLG_1					.61	▨	.07	.32		▨	28
$(CAAT)_2$	TN_2		▨			▨	▨	▨				
	TLG_2			▨							▨	

Table 9. Transition Proportions 1968/69 by Program Type in CAAT

1968 ↓ → 1969		$(CAAT)_1$			$(CAAT)_2$		$(CAAT)_3$	Labor Force				Total Enroll-ment
Level	CAAT Program	TA_1	TN_1	TLG_1	TN_2	TLG_2	TLG_3	P	W	F	GRAD	
$(CAAT)_1$	TA_1				▨	▨	▨	▨				
	TN_1				.71	▨	▨	.01	.26	.02	▨	82
	TLG_1					.87	▨		.13		▨	15
$(CAAT)_2$	TN_2		▨			▨	▨	▨	.20* .80			35
	TLG_2			▨			.94		.06		▨	17

*conditional

Table 10. Student Flow, Technicians by Course, 1st Year

	1968 →	TN$_2$					Labor Force			Total Enrollment
↓ 1967	Course	Construction	Electrical	Electronic	Industrial	Mechanical	P	W	F	
TN$_1$	Construction	-					-	-	-	0
	Electrical		6					2		8
	Electronic			12				2		14
	Industrial				9					9
	Mechanical					8	1	4	2	15

	1969 →	TN$_2$					Labor Force			Total Enrollment
↓ 1968	Course	Construction	Electrical	Electronic	Industrial	Mechanical	P	W	F	
TN$_1$	Construction	18						3		21
	Electrical		10				1	5	1	17
	Electronic			8				4		12
	Industrial				12			6	1	19
	Mechanical					10		3		13

We now turn to the analysis of the effects of high school achievement on students' progress through the college. Tables 11, 13, and 15 show the flows in the 1967/68 session for population classes defined by three intervals of high school average. As would be expected, there is a tendency for passing rates to improve as high school average increases. The exceptions to this trend are indicated by asterisks in the appropriate cell. For instance, the two students who withdrew from the first year technologists' program (table 13), having had an average of over 70% in high school, are indicated as leaving for reasons other than deficiencies in their academic performance.

This same trend is not at first evident from the corresponding 1968/69 figures (tables 12, 14, 16). It can be seen from table 16 that there were a surprisingly large number of withdrawals from among first-year technicians with a high school average of 60 to 69.9%. Further analysis of this group would appear to be justified.

As was indicated previously the 1968/69 session saw a significant increase in new entrants to technician courses from Arts and Science high school programs. Of these students, 44.4% had high school averages between 50 and 59.9%, 13.0% between 60 and 69.9%, and 56.3% had 70% or over. The passing rates for such students, irrespective of high school average, was consistently high: 75.7% of those with 50 to 59.9%, 83.3% of those with 60 to 69.9%, and 77.8% of those with 70% or over. The same pattern held for Science, Technology, and Trades students, with the exception of those with 60 to 69.9% high school averages. This fact, then, narrows down the inconsistent group to students entering from Science, Technology, and Trades programs in high school with percentage averages in the 60s. Furthermore, it was found that every student in this group was from a 4-year program, and 78.6% of them were either 19 or 20 years old when entering the program

Table 11. Student Flow 1967/68 for Students with High School Percentage of 50 to 59.9

↓ 1967 → 1968		$(CAAT)_1$			$(CAAT)_2$		$(CAAT)_3$	Labor Force				Total Enroll-ment
Level	CAAT Program	TA_1	TN_1	TLG_1	TN_2	TLG_2	TLG_3	P	W	F	GRAD	
$(CAAT)_1$	TA_1				▨	▨	▨	▨				
	TN_1				8	▨	▨		4	1	▨	13
	TLG_1					5	▨	1	2		▨	8
$(CAAT)_2$	TN_2		▨			▨	▨	▨				
	TLG_2			▨							▨	

Table 12. Student Flow 1968/69 for Students with High School Percentage of 50 to 59.9

↓ 1968 → 1969		$(CAAT)_1$			$(CAAT)_2$		$(CAAT)_3$	Labor Force				Total Enroll-ment
Level	CAAT Program	TA_1	TN_1	TLG_1	TN_2	TLG_2	TLG_3	P	W	F	GRAD	
$(CAAT)_1$	TA_1				▨	▨	▨	▨				
	TN_1				15	▨	▨		3		▨	18
	TLG_1					4	▨				▨	4
$(CAAT)_2$	TN_2		▨			▨	▨	▨			8	8
	TLG_2			▨			4		1		▨	5

Table 13. Student Flow 1967/68 for Students with High School Percentage of 60 to 69.9

↓1967 → 1968		(CAAT)$_1$			(CAAT)$_2$		(CAAT)$_3$	Labor Force				Total Enroll-ment
Level	CAAT Program	TA$_1$	TN$_1$	TLG$_1$	TN$_2$	TLG$_2$	TLG$_3$	P	W	F	GRAD	
(CAAT)$_1$	TA$_1$				▨	▨	▨	▨			2	2
	TN$_1$				17	▨	▨	1	2	1	▨	21
	TLG$_1$					10	▨	1	2		▨	13
(CAAT)$_2$	TN$_2$		▨			▨	▨	▨				
	TLG$_2$			▨							▨	

Table 14. Student Flow 1968/69 for Students with High School Percentage of 60 to 69.9

↓1968 → 1969		(CAAT)$_1$			(CAAT)$_2$		(CAAT)$_3$	Labor Force				Total Enroll-ment
Level	CAAT Program	TA$_1$	TN$_1$	TLG$_1$	TN$_2$	TLG$_2$	TLG$_3$	P	W	F	GRAD	
(CAAT)$_1$	TA$_1$				▨	▨	▨	▨				
	TN$_1$				28	▨	▨	1	15	2	▨	46
	TLG$_1$					6	▨		1		▨	7
(CAAT)$_2$	TN$_2$		▨			▨	▨	▨			17	17
	TLG$_2$			▨			10				▨	10

Table 15. Student Flow 1967/68 for Students with High School Percentage >70

1967 ↓ → 1968		(CAAT)$_1$			(CAAT)$_2$		(CAAT)$_3$	Labor Force				Total Enroll-ment
Level	CAAT Program	TA$_1$	TN$_1$	TLG$_1$	TN$_2$	TLG$_2$	TLG$_3$	P	W	F	GRAD	
(CAAT)$_1$	TA$_1$				▨	▨	▨	▨				
	TN$_1$				9	▨	▨		1		▨	10
	TLG$_1$					2	▨		2*		▨	4
(CAAT)$_2$	TN$_2$		▨			▨	▨	▨				
	TLG$_2$			▨							▨	

*1 (4A&S) obtained employment
1 (4ST&T) not interested

Table 16. Student Flow 1968/69 for Students with High School Percentage >70

1968 ↓ → 1969		(CAAT)$_1$			(CAAT)$_2$		(CAAT)$_3$	Labor Force				Total Enroll-ment
Level	CAAT Program	TA$_1$	TN$_1$	TLG$_1$	TN$_2$	TLG$_2$	TLG$_3$	P	W	F	GRAD	
(CAAT)$_1$	TA$_1$				▨	▨	▨	▨				
	TN$_1$				13	▨	▨		3*		▨	16
	TLG$_1$					1	▨		1**		▨	2
(CAAT)$_2$	TN$_2$		▨			▨	▨	▨			9	9
	TLC$_2$			▨			2				▨	2

*1 (4A&S) returned to high school **1 (4A&S) got job
1 (5A&S) financial problems
1 (4ST&T) no interest in course (industrial)

(none less than 19). The reasons for withdrawal assigned to this group of students were nearly all concerned with low marks or failure to write examinations. Without further information it is not possible to explain the withdrawal pattern described above. It is not known, for instance, whether the students with the characteristics outlined had some other characteristic which distinguished them from similar students who did not withdraw. Did they perhaps come straight from high school after one or more grade repetitions or possibly with a weakness in specific subjects, such as mathematics? Is there perhaps a lack of standardization of grade marking between individual schools or high school programs? Or was it the larger enrollment of 1968/69 in technician courses which led to more rigorous course standards, which, coincidentally, affected those with 60 to 69.9% high school averages? Such questions are unanswerable in the context of the information available for this analysis, but do serve to identify incongruities which might be investigated further at the college level.

As was mentioned previously, the duration of high school program was a somewhat unreliable data item in view of the uncertainity as to completions of the indicated programs. However, in tables 17, 18, 19, and 20, we are able to compile student flows for population classes defined by high school program type--Arts and Science or Science, Technology, and Trades. There appear to be no remarkable differences in the transition behavior of the two population classes with respect to high school program type with the exception of the incongruity, indicated before, concerning students enrolled in the first-year technician program 1968/69, with 60 to 69.9% averages in ST&T program type in high school.

Table 17. Student Flow 1967/68 for Students Entering from Arts and Science Programs

↓1967 → 1968		(CAAT)$_1$			(CAAT)$_2$		(CAAT)$_3$	Labor Force				Total Enrollment
Level	CAAT Program	TA$_1$	TN$_1$	TLG$_1$	TN$_2$	TLG$_2$	TLG$_3$	P	W	F	GRAD	
(CAAT)$_1$	TA$_1$				▨	▨	▨	▨			2	2
	TN$_1$				4	▨	▨		3		▨	7
	TLG$_1$					11	▨	1	6		▨	18
(CAAT)$_2$	TN$_2$		▨			▨	▨	▨				
	TLG$_2$			▨							▨	

Table 18. Student Flow 1967/68 for Students Entering from Science, Technology, and Trades Programs

↓1967 → 1968		(CAAT)$_1$			(CAAT)$_2$		(CAAT)$_3$	Labor Force				Total Enrollment
Level	CAAT Program	TA$_1$	TN$_1$	TLG$_1$	TN$_2$	TLG$_2$	TLG$_3$	P	W	F	GRAD	
(CAAT)$_1$	TA$_1$				▨	▨	▨	▨				
	TN$_1$				30	▨	▨	1	5	2	▨	38
	TLG$_1$					4	▨	1	3		▨	8
(CAAT)$_2$	TN$_2$		▨			▨	▨	▨				
	TLG$_2$			▨							▨	

Table 19. Student Flow 1968/69 for Students Entering from Arts and Science Programs

1968 ↓ → 1969		(CAAT)$_1$			(CAAT)$_2$		(CAAT)$_3$	Labor Force				Total Enroll-ment
Level	CAAT Program	TA$_1$	TN$_1$	TLG$_1$	TN$_2$	TLG$_2$	TLG$_3$	P	W	F	GRAD	
(CAAT)$_1$	TA$_1$											
	TN$_1$				18				5			23
	TLG$_1$					8			1			9
(CAAT)$_2$	TN$_2$										1* / 3	4
	TLG$_2$						10		1			11

*conditional

Table 20. Student Flow 1968/69 for Students Entering from Science, Technology, and Trades Programs

1968 ↓ → 1969		(CAAT)$_1$			(CAAT)$_2$		(CAAT)$_3$	Labor Force				Total Enroll-ment
Level	CAAT Program	TA$_1$	TN$_1$	TLG$_1$	TN$_2$	TLG$_2$	TLG$_3$	P	W	F	GRAD	
(CAAT)$_1$	TA$_1$											
	TN$_1$				38			1	16	2		57
	TLG$_1$					3			1			4
(CAAT)$_2$	TN$_2$										6* / 24	30
	TLG$_2$						4					4

*conditional

A few brief comments, now, on the influence of the remaining background characteristics--age at entry and father's occupation. The most successful students, as measured by the proportion who continued into the second year of their program, were those recorded as being 22 years old or more at entry. Of the 17 students in this age category, 94.1% were thus successful. Similar results were obtained by those entering at ages of 17 or 18. For this, the youngest age group, 89.5% out of 38 remained in their programs.

Those students in the two intermediate age-at-entry categories--19 and 20-21--appear to be relatively vulnerable to withdrawal or failure; only 63.6% of the 66 people in the former group and 62.0% of the 50 in the latter continued into their second year.

The relative success of both the oldest and the youngest age groups would suggest that motivation plays a dominant role in affecting performance in the college technical division, particularly since high school average was seen to be only a marginally good indicator. It seems reasonable to expect the oldest age group to be highly motivated to complete their programs; they presumably have greater responsibilities and are deliberately forgoing accustomed earnings in order to upgrade their qualifications by taking advantage of this new local facility. Those students entering a program at an age of 18 or less have presumably experienced little difficulty in high school and have chosen to pursue their higher education in a CAAT as a viable alternative to university. (The majority of them, judging by high school results, would seem to have had excellent prospects of entering university if they had remained in high school.)

The relatively high attrition amongst students entering the technical division between the ages of 19 and 21 might well be associated with a lesser degree of motivation to complete their programs, although this must remain pure conjecture on the basis of data available to the present analysis. Many plausible explanations might be advanced to account for this phenomenon: for example, there might well have been more career indecision among this age group, leading them to enroll in the college by accident rather than design as an escape from dead-end jobs or lack of employment opportunities. Clearly, the lure of larger urban centers for the youth of the college area must also have played a part in some of the voluntary withdrawals.

We have noted elsewhere the inadequacy of the "father's occupation" data item for the purposes of useful classification. However, employing the somewhat crude classification of this characteristic adopted for tables 2 and 3, it appears that those students whose fathers' occupations were categorized as semi-skilled and unskilled were more likely to proceed into the second year of their programs than were the sons of professional and skilled fathers. The proportion of each population class, as defined by father's occupation, which continued into the second year of a program for 1967/69 were as follows:

Professional - 66.7% of a total of 9,
Skilled - 58.3% of a total of 24,
Semi-skilled - 77.0% of a total of 61,
Unskilled - 72.7% of a total of 77.

The first three groups had somewhat better results in the technologist program than in the technician, whereas the reverse was true for the unskilled-father category. Also the students whose fathers were professionals enrolled more frequently in the technologist program than did any of the other categories: 44.4% of the former group as opposed to approximately 24% of the latter three.

As for comparisons between high school average and "father's occupation" classes, the classes of students defined by less-qualified fathers have had significantly better results in high school. For example, 22.9% (16 students) of the sons of unskilled workers had achieved an average in high school of 70% or more. This compares with 19.6% (11 students) of the semi-skilled, 4.2% of the skilled (1 student), and 11.1% of the professional workers (1 student). (Note: Some students' records have the high school average data item missing.)

It would appear, then, that the technical division attracted the great majority of its students from the semi-skilled and unskilled fathers' occupation categories, and furthermore, such students have generally better results in high school than their contemporaries from the other categories. This is not really a surprising result; high-achieving students with professional or highly trained parents probably aspire to university education and/or nontechnical professions, such as teaching or business.

A particular "father's occupation" of considerable interest, in view of the rural nature of much of the area served by this particular college, is that of farmer. Students with this background characteristic were apparently highly successful in high school; 36% of the 22 farmers' sons had a high school average of 70% or more, compared with 22.9% of all the unskilled-father category and 19.7% of all students enrolled. They also constituted a relatively young group, 45.5% of them being 18 years of age or younger upon entering the college, as opposed to 22.2% for all new entrants. A high proportion (81.8%), continued into the second year of their program (almost a third were enrolled in the technologist program), which compares with the overall retention rate for all new entrants of 72.0%. In fact, of the four withdrawals by farmers' sons, two passed the session and withdrew without giving any reason, while another obtained employment during the year. The foregoing analysis of farmers' sons enrolled in the college's technical division may well reflect the lower aspirations of rural youth, insofar as only the most able of them (entering relatively young and having been successful in high school) had persevered in formal education to the post-secondary level. It would seem, then, that the college's technical division has opened up an important avenue of occupational mobility for rural youth and is playing a role similar to that of local university engineering faculties for the brighter children of low-income families in large urban centers.

CHAPTER 3: BENEFITS, LIMITATIONS AND EXTENSIONS

3 - 1. Benefits

The most immediate benefit arising from the regular construction of empirical transition matrices is the exposure of a whole new area of relevant information about behavior of students, teachers, and others, which would otherwise be ignored or merely guessed at. The annual compilation of stock enrollment data alone, however detailed, makes the estimation of repeaters, transfers, and dropouts exceedingly difficult, if not impossible. The attempt to disentangle real changes in transition behavior from the effects of fluctuating enrollment is demonstrably fruitless with such aggregated data.

In a single table (transition matrix), then, a concise picture of student progression could be brought to the attention of educational administrators and policy-makers. The monitoring, year by year, of such information would immediately highlight any abnormal or detrimental changes in student flow and thus provide the impetus for more detailed investigation into causes and/or remedies. In addition, the tables produced by partitioning students into population classes would furnish the best available information for realistic comparisons of student characteristics or alternative programs.

If the various population classes considered display relatively different transition behavior in their progress through some educational subsystem such as secondary schools, universities, or CAATs, then as the class spectrum of new enrollments changes with time, the subsequent stocks both for states within the subsystem and in terminal states (output states, higher education, labor force, dropouts) may be completely unexpected in comparison with extrapolations of present stocks. If such counter-intuitive insights are detected in advance, considerable frustration and misallocation of resources can be avoided.

Let us now illustrate the foregoing benefits of empirical transition matrices by means of an example, demonstrating as it does their implications for relevant educational decision-making. The Carnegie Study (3) provided one of the few data sources from which flow information in Ontario schools could be determined. The flow tables compiled by McReynolds (2) for the single cohort of 90,000 students counted in grade 9 in 1959 could be used in the following manner.

All the grade repetitions experienced by this single cohort are counted, and result in a total of 34,319 repetitions. Now, the number of repetitions can be considered to be in some sense a measure of <u>performance</u> of a school system, since certain direct and indirect costs are associated with each repetition. In other words, these are the costs associated with an extra 34,319 student years. (note: Accelerations and double promotions are negligible in comparison with repetitions.)

The direct costs are clearly the financial costs associated with teachers' salaries, school equipment, and space requirements. Let us assume the very conservative average figure of $500 per student year to cover these costs. Then it follows at once that the direct costs alone for this single cohort repeating one year of secondary school amount to at least $17 million. Since a new cohort would have entered grade 9 in each year subsequent to 1959, the actual number of repetitions in this period would be considerably inflated (assuming similar repetition rates).

The indirect costs incurred to both the student and society are probably more serious. For instance, even if a student eventually attains his target educational level, his entry into the labor force will have been delayed by the repetition (or repetitions) experienced in secondary school, and thus entail a loss of income for him and the loss of a potentially productive member to society. Alternatively, if, as appears more likely, the discouragement caused by his repetitions leads to his prematurely dropping out of school, the amount of his personal frustration and wasted potential talent are incalculable.

Having thus diagnosed, by the inspection of a flow matrix, a possible area for improvement in secondary school policies, the appropriate decision-maker might then ask whether the situation is unavoidable, and, if not, whether perhaps some alternative structure might reduce or eliminate some of these costs. To answer these questions he might then investigate the characteristics of the repeaters by partitioning them into population classes, defined by such attributes as IQ, socioeconomic class, student/teacher ratios, or geographical region, and then compile transition proportion tables for these classes. The results of this latter analysis should determine whether academic inability or disaffection, perhaps caused by inappropriate curricula or high student/teacher ratios, was responsible.

In any event, the exercise might isolate major components, which would then suggest possible modifications of present policies, such as new branches. At the same time, it might be judged that no major improvements could be achieved by mere modification of the extant system, perhaps because of its inflexibility of structure and its inability to encompass all the varieties and interests of participating students.

Whatever the outcome, this would seem to be a highly profitable area for further investigation.

Another important benefit arising from the compilation of transition proportion matrices is that they provide a powerful technique for projection of future stocks and enrollments. If the hypothesis of the constancy of the transition proportion matrix can be justified, then the recurrence relationship of equation (12), chapter I, provides a simulation model of enrollment. As has been indicated previously, such a simulation model is considerably more powerful than any based upon trend extrapolation.

The details of the method and its application to Ontario secondary school grade and branch enrollments 1959-1964 will be found in (2).

Finally, it must be said that the greatest benefit probably derives from the exercise of analysis itself together with the spin-off benefits of suggesting relevant data requirements for educational decision-making. This latter topic will be pursued in the next section.

3 - 2. Information Requirements and Limitations of the Method

By far the greatest impediment to the creation of empirical transition matrices is the current inadequacy of regularly collected and sufficiently comprehensive data.

The method described in the previous chapters implies the existence of a coordinated and purposeful procedure of data collection (information system) for its effective application. At present, very few educational jurisdictions collect student and staff data in a form suitable for analyzing even their internal transitions. They certainly collect student data by such means as registration forms, academic records, and so on. but does this constitute information that relates to decisions that have to be made?

The most suitable method of data collection, in terms of flexibility and accessibility for planning and monitoring, would appear to be the creation of standardized individual student record files effectively utilizing computers as the storage medium. Such records would contain the following areas of information for each student:

(a) Some unique identification code.

(b) A set of permanent characteristics considered relevant to decision-making: year of birth, sex, predictions, etc.

(c) An up-to-date ordered list of the states through which the subject has passed, within the system (or subsystem), together with any changes occurring in each--examination results, certification, etc.

(d) Information linking the subject with other subsystems, including verified origin before entry, and verified destination upon exit.

The questions of <u>what</u> data to collect and <u>how</u> to collect it will ultimately be determined by the definitions of the educational states of the conceptualized system. Items (b) and (d) above could well be collected by questionnaire, completed as part of initial registration procedures or certification procedures. However, if the method of empirical transition matrices and the mathematical models derived from it are to be used for regular monitoring and projection, the student records would have to be updated whenever a change in the system occurred (usually every year for the grade-branch system of secondary schools). There is also the possibility of modifying and expanding existing manual data-collection procedures, such as the O.S.R. folder of Ontario schools, provided that uniformity of implementation could be guaranteed.

Standardization of data elements between the subsystems of formal education would certainly be an advantage from the point of view of decision-making agencies with wider jurisdictions, such as the Department of Education and commissions for postsecondary education. However this would involve the collaboration of many autonomous agencies and institutions, which might obstruct the collection of such data by a "centralized" authority. In these cases, particularly among the institutions of higher education, the public responsibilities of those concerned should be given priority over the interests of various sectors, particularly since the real benefits of autonomy need not be infringed.

A similar controversy might arise over the question of confidentiality of student records, and clearly some protective devices and procedures would have to be developed to satisfy this requirement. It should be pointed out, in this respect, that the purpose of an information system as described above is to evaluate the functioning of the educational process rather than to make decisions about individual students. Rarely, if ever, would identifiers such as names and addresses be accessible, and even then under strict control regulations. Also the right of a student or teacher to inspect and verify his record would be a necessity.

Although the storage and retrieval of individualized student data of this type could become a major (but straightforward) undertaking, a more serious problem is posed by the need for regular updating of stored files and the creation of new files. We should not underestimate the difficulties of linking manually collected data such as registration forms and examination results, from possibly many different sources, to an automatic storage and processing device. Well-defined and foolproof coding, checking, and error-correction procedures would have to be devised. However, satisfactory precedents exist in other fields and these problems should not be insurmountable.

3 - 3. Extensions

The foregoing chapters have concentrated upon students and the various systems that could be devised in which they were the elements. The decision-makers were assumed to be administrators or planners with responsibilities for the education of these students in environments such as secondary schools, CAATs, and universities.

It must be borne in mind, however, that the students themselves are decision-makers and as such require considerable information wherever they are faced with a choice. Perhaps the two most important choices faced by students in their educational histories are the selection of a postsecondary school institution and specialty, subject, or course, and the selection of an occupation or profession on completion of formal education. In order to make rational choices, then, students must have access to a good deal of information related to admissions policies, difficulty of courses (as demonstrated by previous student progressions), prospects of employment for graduates, salaries, etc.

These areas of information also coincide with the requirements of administrators of postsecondary education and provincial economic and industrial decision-makers. Thus, it would appear that a valuable area for the application of empirical transition matrices would be the education-employment system.

The defined system states would depend upon which decisions were involved--those of students, administrators, or economists. All such systems could be constructed, however, from an individualized student information system as advocated in the previous section. For students' use, for example, the states could be suitably defined: the year and course within the institution(s); the labor force, subdivided by industry of employment, highest formal educational qualification required, or initial salary levels; and the inactive (unemployed) labor force. Economists, on the other hand, would probably prefer to partition the labor-force destination states by occupational skills and industrial and professional sectors.

Transition matrices for teachers could also be prepared, given coordination of annual teacher appointments records. These would show the proportions of teachers who remain in the profession, who enter it from teachers' colleges, universities, or immigration, and who leave for retirement or other.

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