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ABSTRACT

Described for Federal and State policymakers is an analytic model of special education (SE) manpower incorporating questionnaire data from 1,173 SE students and 2,068 SE teachers. The model is reported to encompass the following 13 states or definable conditions: undergraduate training; five states each for undergraduate and masters degree levels consisting of full-time teacher in SE, full-time teacher in SE and part-time school attendance for a higher degree, full-time student, out of SE and part-time student, and out of SE and no school attendance; and two states (in or out of the SE field) at the post-masters degree level. Methodology is given to include categorization of students by the three educational levels according to the specialty areas of sensory disorders, learning disorders, and other specialties; and categorization of teachers on bases such as representation from 26 states and school districts. Noted is use of career data such as length of time in jobs and nature of current position. Analysis of version 1 (state probabilities) involving matrix computation is explained through results indicating that of 128 female teachers specializing in sensory disorders, 48 teach full-time with an undergraduate degree, 49 teach with a masters degree, one teacher in the field has a doctorate, four teachers are in school full-time, and four teachers have left the field. Explained is analysis by version 2 (incorporating time in state) involving ways to interpret movement of teachers in the field. Given are examples of model operations such as projecting the current states ahead for 1 year. (MC)

DEVELOPMENT AND APPLICATION OF A MANPOWER CAREER FLOW MODEL OF SPECIAL EDUCATION TEACHERS

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DEVELOPMENT AND APPLICATION OF A MANPOWER CAREER FLOW MODEL OF SPECIAL EDUCATION TEACHERS[1]

by

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INTRODUCTION

This paper is a revision of part of the final report of an evaluation study of Federal Programs to Increase the Pool of Special Education Teachers. These programs are conducted under Title VI, Part D, of Public Law 91-230 by the Bureau of Education for the Handicapped (BEH). The fundamental federal objective is to provide an equal educational opportunity to all handicapped children. The thrust of the Bureau's efforts has been in two major directions: (1) development of programs in the school systems and institutions to provide more Special Education services to children in need of them, and (2) development of training programs to increase the supply of personnel necessary to provide such services.

Programs of the latter type were the focus of the study. Grants have been provided to institutes of higher education for undergraduate traineeships at the junior and senior level, and for graduate fellowships (Master's and post-Master's level). Universities and colleges have also been funded for summer traineeships,

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1. The research reported herein was performed by RMC Research Corp. of Bethesda, Md., pursuant to a contract OEC-0-71-3702 with the Office of Education, U.S. Department of Health, Education and Welfare. Contractors undertaking such projects under government sponsorship are encouraged to freely express their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

2. Mr. Carl Blozan, formerly of RMC Research, is now with the Food and Drug Administration. Mr. Hass is with RMC Research Corp.

special study institutes, and program development. In addition, grants can be provided to institutions of higher education to train personnel in physical education and recreation for the handicapped. State education agencies (SEAs) are provided grants for undergraduate traineeships, graduate fellowships, summer traineeships, special study institutes, and workshops. State education agencies and universities are also eligible for special project grants to plan to try new models of training for Special Education and to evaluate them.

During fiscal 1971, 304 institutions were receiving P. L. 91-230 (Title VI, Part D) funds and providing undergraduate traineeships to 1,783 students and graduate fellowships to 2,814 students. In addition, funds channeled through state education agencies provided direct support for 5,727 summer trainees and 11,850 institute trainees.[1] These levels of activity must be viewed in three perspectives: total training activity for Special Education, total "needs" for trained Special Education personnel, and effective demand for such personnel.

As to total training activity, an increasing number of students have been entering training for education of the handicapped. It is estimated, for example, that in 1968-69[2] a total of 58,468 undergraduate and 26,162 graduate students, for a total of nearly 85,000 full-time and part-time or extension students were enrolled in preparation programs for education of the handicapped. This represented a 370-percent increase in the number of students enrolled in preparation programs between 1961-62 and 1968-69.

As to need, it has been estimated that 3.75 million, or 62 percent of the six million handicapped children in the nation in 1968-69 received no appropriate Special Education service in that year.[3] For the same year it was estimated that

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1. U. S. Office of Education, BEH, Annual Evaluation Report on Education Programs, January, 1972.

2. U. S. Office of Education, BEH, Students in Training Programs in the Education of Handicapped Children and Youth, 1968-69 (July, 1970).

3. U. S. Department of Health, Education and Welfare, Programs for the Handicapped, September 4, 1970.

124,000 Special Education teachers were available and 323,000 additional teachers would be required to accommodate the unfilled need. The relative gap between need and supply varies by type of disability. The BEH figures for 1968-69 indicated that 52 percent of the mentally retarded, 21 percent of hard of hearing and deaf, 51 percent of the speech impaired, 34 percent of the visually handicapped, 13 percent of the emotionally disturbed, 33 percent of the crippled, 15 percent of the other health-impaired, and 26 percent of the multi-handicapped were receiving Special Education services.

While university-based programs for Special Education teachers and graduates of these programs have increased, the shortage relative to needs is far from having been eliminated. This shortage, however, should also be viewed in light of the availability of jobs for Special Education teachers. While the number of handicapped children can be translated into a need for teachers, as above, the true current demand for Special Education teachers must reflect the number of funded slots available. That is, consideration of the supply of Special Education teachers--which includes practicing teachers, new graduates, and other teachers receiving certification through specialized training--should take into account effective demand as well as need.

BEH, like any other agency, must choose among alternative courses of action (program strategies) in ways that will maximize the impact of its limited funds. To do this, it must make judgments as to the effectiveness of current program strategies and the potential effectiveness of alternatives. Hence, the objectives of the study were:

(1) to evaluate the impact of Title VI grants in order to determine what level or combination of levels of funding are most effective in increasing the pool of Special Education teachers,

(2) to examine the career histories of practicing Special Education teachers in order to identify the most productive type of training programs, and

(3) to assess alternate strategies available to BEH in order to better utilize available funds for increasing the pool of practicing Special Education teachers.

These broad objectives were pursued by collecting and analyzing data from four main sources. One source was a mail survey of a sample of Special Education undergraduate and graduate students funded by BEH (via universities and SEAs) in 1968-69, matched by a sample of Special Education students at the same institutions who were not funded by BEH. Another was a mail survey of a sample of practicing Special Education teachers intended to be as representative as possible of the natural Special Education teacher pool. Other sources were a survey of universities and state education agencies.

This paper describes an analytic model of Special Education manpower that was developed to analyze the career histories of teachers and students. The model provides a method for computing the probabilities of teachers occupying certain outcome states after a given number of years since receiving Bachelor's, Master's, or post-Master's degrees. It will be shown that the model allows for an appraisal of the impact of hypothetical changes in federal policy on the supply and retention of Special Education teachers. Included in this paper are additional analyses of the students and teachers, developed via the model.

MODEL CONCEPT

The model was developed to help assess the alternative federal strategies available and to trace the career histories of teachers and students and is based upon a Markov chain-type of analysis. Quite simply, Markov processes are concerned with the probability that a given entity (say a Special Education teacher) will change (or remain in) the state that defines his or her position in the next definable time period. Thus, the probability that a practicing teacher will leave the field in the next year or that a teacher out of the field will reenter the field in the next year are examples of changes in state. Indeed it may well be the case that a practicing teacher will continue to be a practicing teacher or that a teacher who is "out" will remain "out" in the next year; such instances depict a maintenance of the current state in the next time period.

If the probabilities of changing from one state to another (or remaining in the same state) can be quantified, then career histories of teachers can be traced and/or projected by use of the Markov process. Certain factors affecting a change in state (such as an increase in pay that might cause a decrease in the probability of leaving the field) can be examined via the model to ascertain their impact on the number of teachers remaining in practice.

The model operates in the following manner. Figure 1 shows a simple three-time period (a year is the time period considered by the model) display of possible states for teachers receiving their undergraduate or Master's degree in year 1. In year 1 there are two possible states:

S1 - receives undergraduate degree, and

S2 - receives Master's degree.

In year 2 there are five possible states:

S3 - out of the field with an undergraduate degree;

S4 - in the field with an undergraduate degree;

S5 - in the field with an undergraduate degree, but attending school part-time;

S6 - in the field with a Master's degree; and

S7 - out of the field with a Master's degree.

In year 3 there are four possible states:

S8 - out of the field with an undergraduate degree,

S9 - in the field with an undergraduate degree,

S10 - in the field with a Master's degree, and

S11 - out of the field with a Master's degree.

The arrows connecting the 11 states show those changes that are possible. Thus, a person cannot change from state S1 (receipt of undergraduate degree) to state S7 (out of the field with a Master's degree) in the next time period. This reflects the fact that, according to the definitions of the states in this example, an

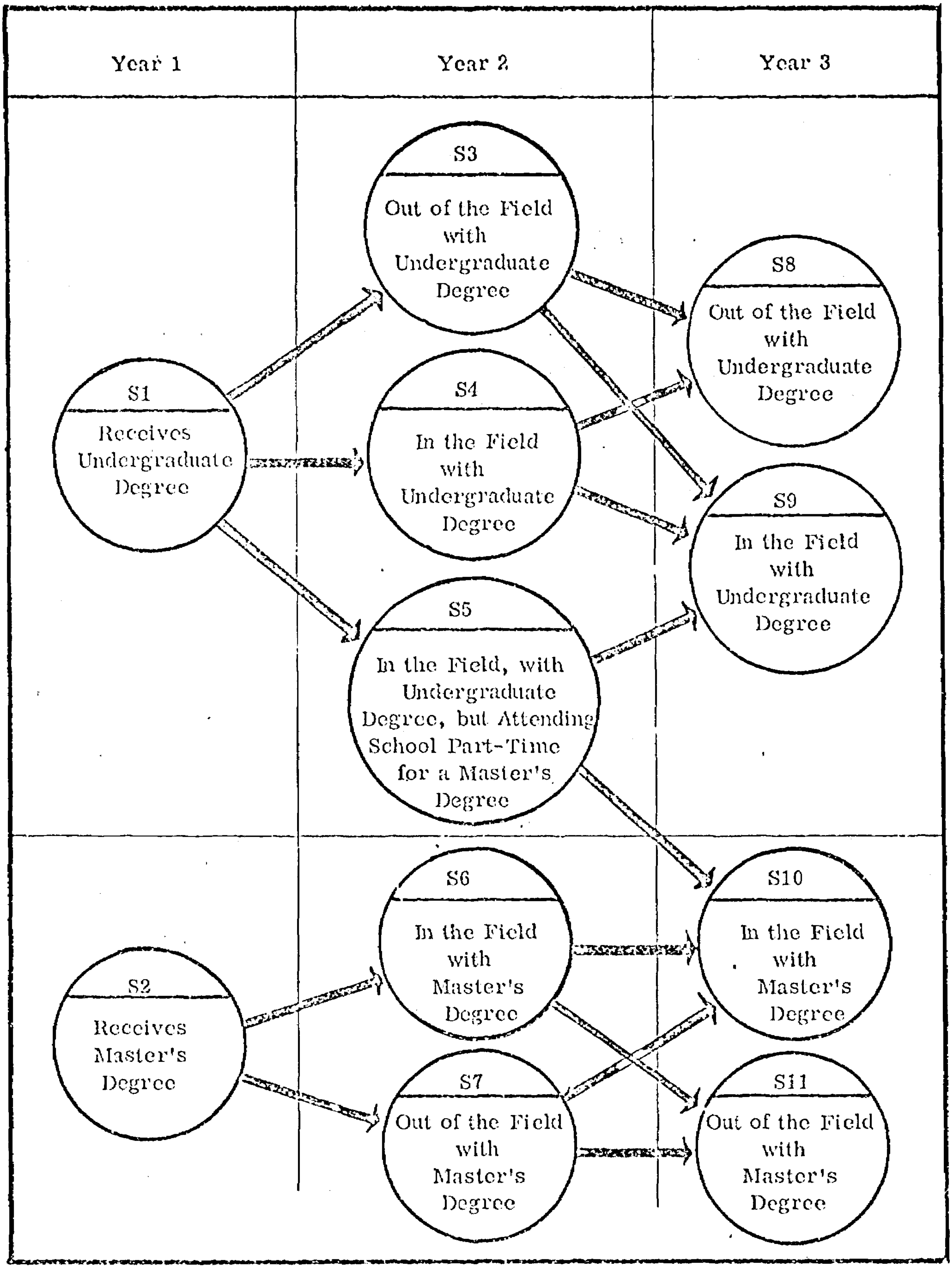

Figure 1: SIMPLE THREE-YEAR DISPLAY OF POSSIBLE STATES OF SPECIAL EDUCATION TEACHERS WITH UNDERGRADUATE OR MASTER'S DEGREE

undergraduate cannot receive a Master's degree without part-time attendance at a school (as denoted by state S5). Similarly, moving from state S5 (in the field with an undergraduate degree, but with part-time attendance at a school towards a Master's degree) to state S10 (in the field with a Master's degree) implies that the teacher received the degree, while moving to state S9 (in the field with an undergraduate degree) implies that the degree being sought was not obtained. Accordingly, states S2, S6, S7, S10, and S11 refer to all those states in which the Master's degree has been received, while the remaining states, S1, S3, S4, S5, S8, and S9 are undergraduate level states.

Another rearranging of states could be used to define the pool of Special Education teachers. In year 2 the pool is all those teachers in states S4, S5, and S6, while in year 3, the pool is made up of those teachers in states S9 and S10.

Data which can be translated into probabilities of moving from one state to another were collected by the survey instrument designed for this study. The method of obtaining and coding these responses is discussed later in this paper. For purposes of illustration, probabilities of moving have been assumed for each arrow shown in Figure 1. Figure 2 shows these values. As can be seen, the sum of the probabilities of leaving each state is 1.0. This reflects the fact that everyone must move to a different state in the next time period. These probabilities are termed transition probabilities as their value reflects the likelihood of moving from one state to another. Thus, when a person receives his undergraduate degree there is a 20-percent chance (probability of .2) that he will leave the field, a .6 probability of entering the field, and a .2 probability of entering the field and attending school part-time for a Master's degree.

To trace a person through a career pattern as shown in Figures 1 and 2, one need only multiply the probabilities together. Thus, to determine the likelihood that an undergraduate degree recipient left the field immediately after graduating and entered the field the year after would mean that the person began in state S1, moved to state S3, and then on to state S9. The probability of doing this is

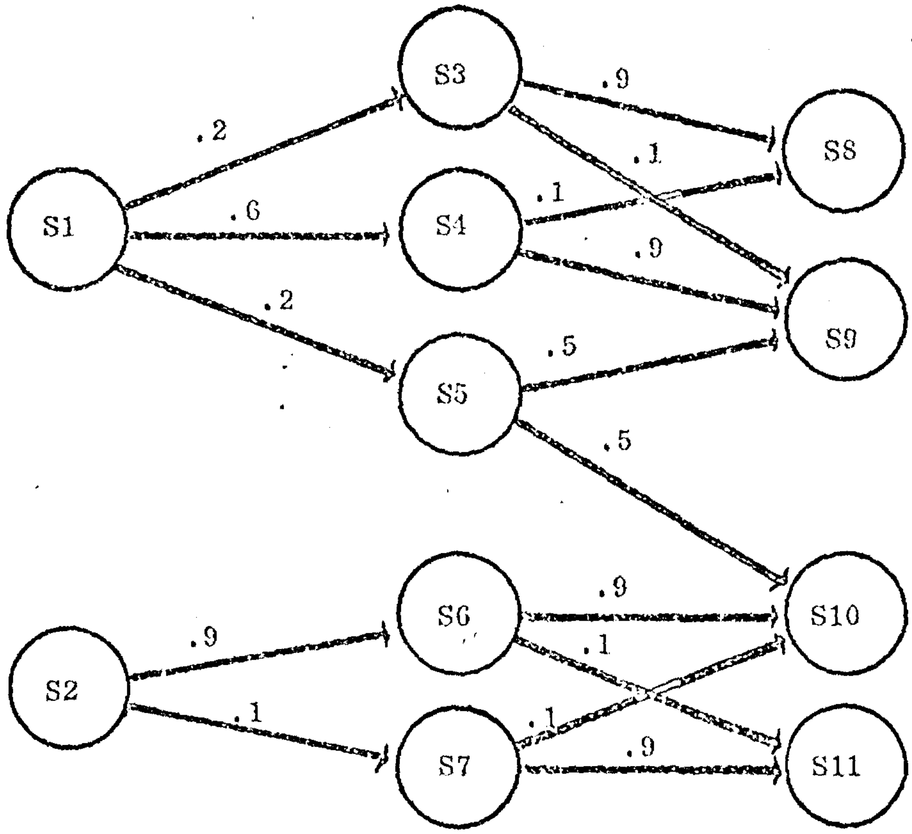

Figure 2: SIMPLE THREE-YEAR DISPLAY OF POSSIBLE STATES OF SPECIAL EDUCATION TEACHERS WITH TRANSITION PROBABILITIES

.2 x .1 or .02. These values are from Figure 2; the .2 is the transition probability of moving from state S1 to state S3, the .1 comes from the probability of moving from state S3 to state S9. The probabilities are multiplied together to develop the probability of going through both states S3 and S9.

This approach was taken for all possible paths to develop the probability of an undergraduate ending up in each of the four possible states as shown in Figure 1. Table 1 shows these results. The value of .24 for state S8 is derived from the fact that a person could arrive at state S8 by either of two paths. If he came via state S3, the probability of reaching state S8 is .2 x .9 or .18. If he came via state S4, this probability was .6 x .1 or .06. These two probabilities are summed to obtain the value of .24. In a like fashion the probabilities of ending up in state S9 and S10 were calculated. An examination of Figure 1 shows that an undergraduate cannot reach state S11 by year 3, hence, this value is zero.

Table 2 shows the values for the Master's students. Again, since states S8 and S9 are undergraduate level states, there is a zero chance of a Master's degree recipient ending up in these states.

The size of the pool of practicing Special Education teachers can now be estimated using Tables 1 and 2 in conjunction with the size of the undergraduate and Master's graduating classes. Recalling that states S9 and S10 comprise the pool of practicing teachers in year 3, .76 of all undergraduates and .82 of all Master's are now found in those two states. Thus, if there were 20,000 undergraduates and 4,000 Master's graduates in year 1, then the size of the practicing pool in year 3, based solely upon the year 1 graduates, would be .76 x 20,000 + .82 x 4,000 or 18,480 teachers. The model that RMC has developed generates each relevant transition probability and the probability of being in any particular state. The values shown in Tables 1 and 2 present the current states of these teachers, if the current time is year 3. Later, more detailed examples will be shown of these probabilities and current states.

Table 1

PROBABILITY OF AN UNDERGRADUATE DEGREE RECIPIENT BEING IN EACH OF THE FOUR STATES

	Year 3 States			
	S8	S9	S10	S11
Probability of Being in Each State	.24	.66	.10	.00

Table 2

PROBABILITY OF A MASTER'S DEGREE RECIPIENT BEING IN EACH OF THE FOUR STATES IN YEAR 3

	Year 3 States			
	S8	S9	S10	S11
Probability of Being in Each State	.00	.00	.82	.18

It is now possible to show how the model can be used to answer some of the "what if" questions that can set federal policy. Suppose it were possible to alter the mix of undergraduate and Master's students graduating each year to 19,000 and 5,000. The same number are graduating each year (24,000), but there are more Master's students. The size of the pool in year 3 would now be .76 x 19,000 + .82 x 5,000 or 18,540, an increase of 60 practicing teachers in addition to the higher level of training possessed by the average teacher, as there are now 720 more teachers with a Master's degree.[1]

As another example, assume that one-tenth of those teachers leaving the field would have stayed if salaries for all teachers were increased by 15 percent. To accommodate this, each transition probability associated with leaving the field is cut by 10 percent and the difference is added to the probabilities of remaining in the field. Figure 3 shows the resultant set of transition probabilities. Exercising the model using these transition probabilities produces the current state tables as shown in Table 3. This table was calculated in the same manner as Tables 1 and 2.

To project the size of the pool in year 3, based upon the 20,000 and 4,000 figures assumed earlier, the pool would now be .783 x 20,000 + .838 x 40,000 or 19,012, an increase of 532 teachers.

When the costs of effecting these changes are associated with each change, the most effective strategy can be selected.

The model actually developed by RMC was more complicated than that described above. However, it is hoped that the above example will suffice to explain how the model works and how the impact of a policy change or change in some aspect controllable can be inserted into the model. Later, when transition probability matrices are shown, they are merely an orderly way to portray the probabilities associated with each arrow in the career pattern flows. Also, when a vector of

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1. The 820 from the 1,000 extra Master's degree recipients minus the 100 undergraduates who would have received a Master's by year 3 on a part-time basis.

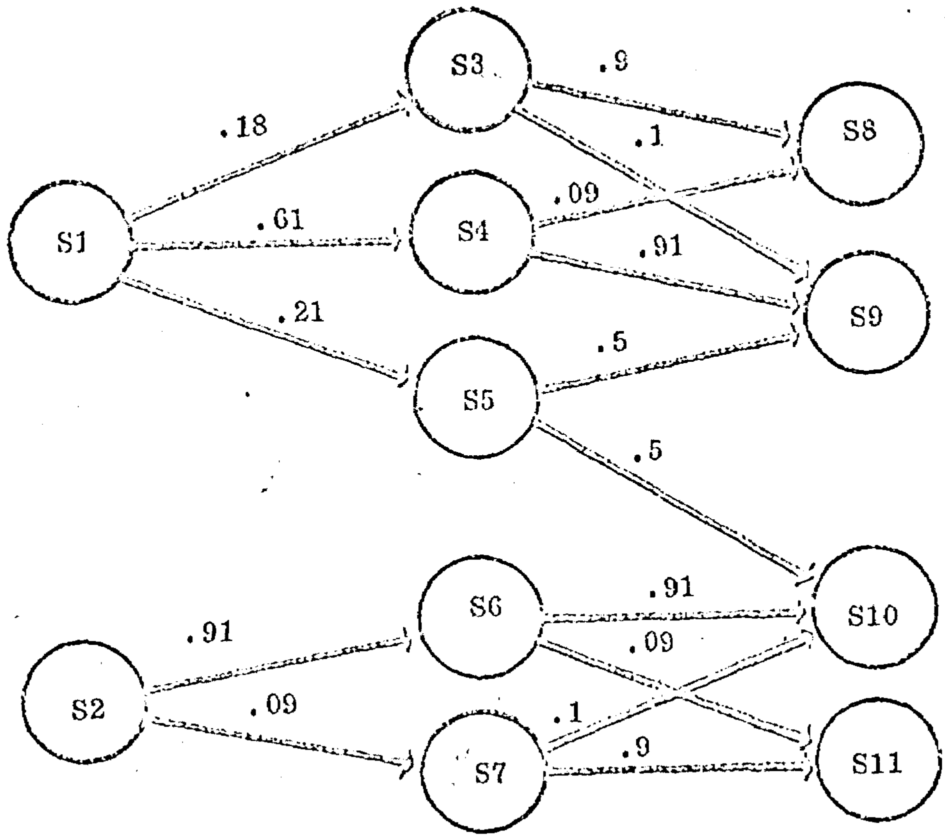

Figure 3: SIMPLE THREE-YEAR DISPLAY OF POSSIBLE STATES OF SPECIAL EDUCATION TEACHERS WITH ALTERED TRANSITION PROBABILITIES

Table 3

PROBABILITY OF AN UNDERGRADUATE OR MASTER'S DEGREE RECIPIENT BEING IN EACH OF THE FOUR STATES IN YEAR 3

Probability of Being in Each State	Year 3 States			
	S8	S9	S10	S11
Undergraduate	.217	.678	.105	0
Master's	0	0	.838	.162

current states is mentioned, it is simply referring to a table such as Table 1 or 2, with the probabilities translated into the number of persons in each state.

One final note: States S4 and S9 are really the same state (in the field with an undergraduate degree) distinguished only by the year in which the state occurs. Thus, they are, in essence, examples of persons remaining in the same state as time progresses. States S3 and S8, S6 and S10, and S7 and S11 are similar situations. In the model developed by RMC, the flow of persons was depicted relative to the states that a person was in, and not relative to the passage of time. Thus, in the next section, where the model actually used is described, a person could remain in one of the states shown for several years.

ANALYSIS OF CAREER HISTORIES AND ALTERNATIVE STRATEGIES USING THE SPECIAL EDUCATION MANPOWER MODEL

The model that RMC developed for this study, based upon the preceding conceptual analyses, will now be discussed. While its prime intent was to examine, in detail, certain aspects of retention, it turned out that--as far as the field of Special Education is concerned--rates of entry are more important than rates of leaving. The preparation of data for the model, however, did produce much useful data, and indeed, model runs were made to show the minimal impact of trying to affect retention. This model could still prove useful in assessing large programs where small changes in retention rates can be translated into significant dollar savings.

While the ensuing discussion may sound somewhat repetitive, it describes the model as actually formulated. The previous section presented a much more simplified version of the model's concept using, however, similar terms.

The model represents a system of states, or definable conditions, under which Special Education teachers are in or out of the field, or undergoing further training, according to their level of education. Thus, it directly addresses Special Education training programs, entry into the teaching pool, and the career patterns of Special Education teachers. Figure 4 displays the set of states and the means of moving from one state to another as used in the model.

The model considers three levels of training for the Special Education teacher --undergraduate, Master's, and post-Master's. At each level it is assumed that he has the degree. For the undergraduates and Master's level teachers, five possible states have been identified. They are:

- in Special Education, meaning a full-time teacher;
- in Special Education + Part-Time, meaning a full-time teacher going to school for a higher degree part-time;
- Full-Time Student, meaning exactly that;
- out of Special Education + Part-Time, meaning not a practicing Special Education teacher, but going to school for a higher degree part-time; and
- out of Special Education, meaning not in the field and not attending school.

For purposes of coding the responses from the questionnaires, all attendance at a university for a higher degree, regardless of the major field, was included. Also, the term "in Special Education" includes teachers, administrators, counselors, etc., as indicated by the respondent.

An undergraduate immediately attains one of the five states described above upon receiving his degree. Similarly, when the teacher obtains his Master's degree, he may also attain any of the five states at the Master's level.

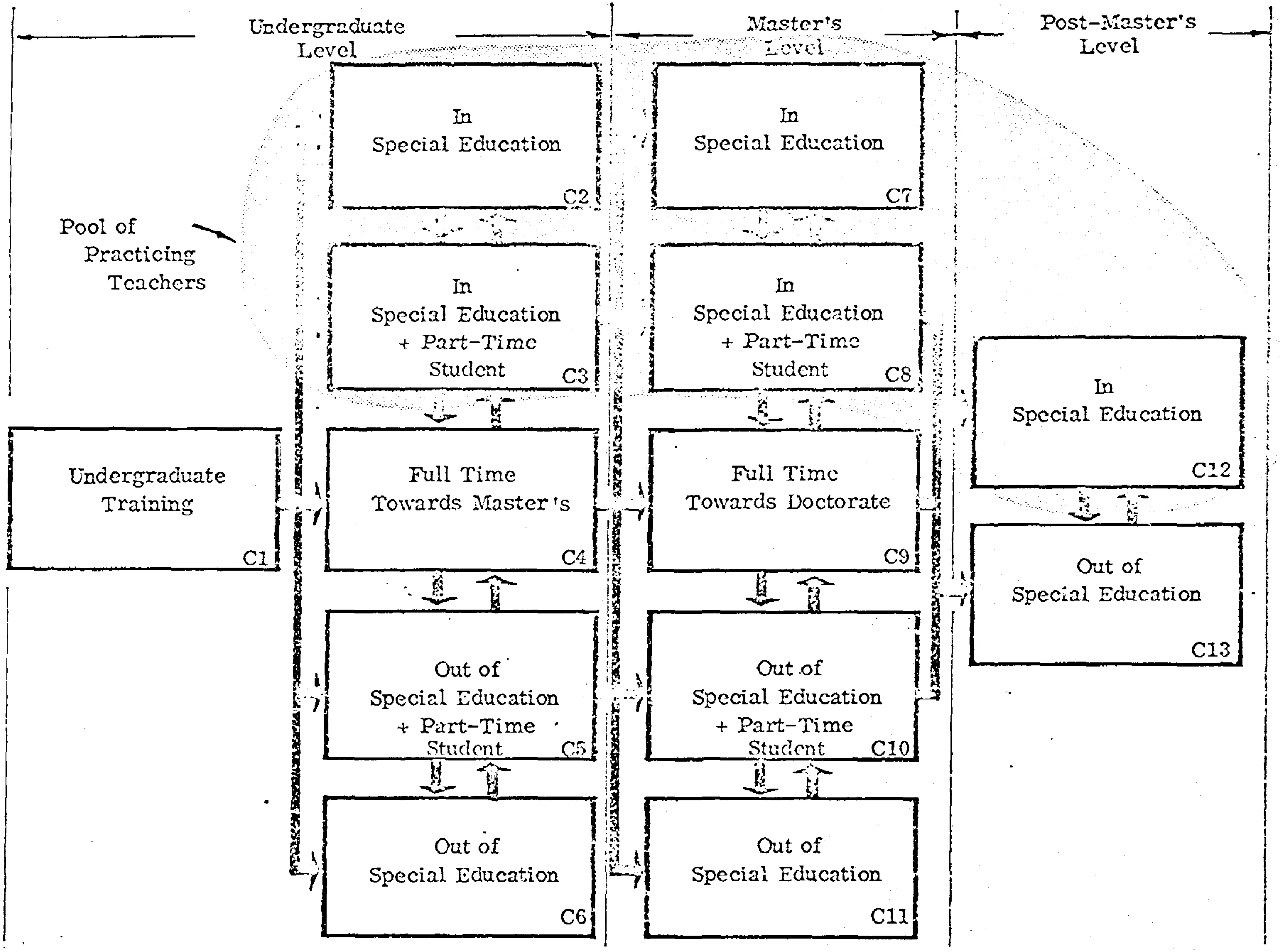

Figure 4: FLOW SCHEME OF SPECIAL EDUCATION MANPOWER MODEL

Within any level, transition from any one of the five states to another is allowed. The time period of evolution is one year--meaning that only one change in state (or remaining in the current state)--is allowed per year. Naturally, during the coding of the responses, some judgment was required to decide which state best described the teacher, if, say, they indicated that they had made more than one change in any given year.

For the post-Master's level, only two states were identified--in or out of Special Education.

It was decided to use the model formulation shown in Figure 4 rather than that developed earlier for the analysis plan because of the lack of data regarding those teachers who were permanently out of Special Education. Thus, no identifiable state for "permanently out" was included. (One can apply, and indeed we have, aggregate mortality and retirement rates, by level, to the number of teachers at each level to estimate this attrition.)

The previous version of the model restricted movement within a level and from one level to another more severely than this version. It is now possible for a teacher to return to another state at the same level after spending one or more years in full-time training. Also, persons can undertake part-time training while being out of the field. Finally, as mentioned earlier within each level, a teacher can move to any state from any other state.

The model was programmed in FORTRAN for a 370/145 computer. It generates the transition probabilities from one state to another (if allowable) as a function of the number of years since Bachelor's degree (state C1), maintains a count of the number of persons in each state, and provides the means of observing in which states teachers are after any specified number of years since receipt of their undergraduate, Master's, or post-Master's degree.

Constraints on the number of teachers placed in Special Education jobs can be made according to limitations on the number of available slots and the number of students receiving undergraduate degrees can be increased or decreased each year based upon university projections.

Finally, the rates of changing from one state to another can be altered to reflect federal or state policy. Thus, transition of teachers into a full-time training slot can be altered to reflect the availability of funding support.

Basic to the development of RMC's model was the generation of a set of definable outcome states, or simply "states," which represent the positions occupied by students or teachers at specified periods of time. Figure 4 illustrated the 13 allowable states used in the model, each denoted by the number appearing in the lower right-hand corner of the state box. States C2, C3, C7, C8, and C12 comprise the pool of practicing teachers, where distinctions among these are functions of the teachers' highest level of educational training and whether or not they are enrolled in a training program on a part-time basis. States C4 and C9 are occupied by students enrolled, on a full-time basis, in a Master's or Doctorate program, respectively. The remaining five states, C5, C6, C10, C11, and C13 are occupied by those individuals who are not practicing Special Education teachers, again allowing for differences in educational level and current part-time student status.

The model is concerned with computing the probability that a person in any state at a given time moves to a new state in the next time period. The time period of resolution was taken as one year, and thus only one change of state (including the possibility of remaining in the current state) is allowed per year. Whereas transition from any state to another within the same educational level is permitted, restrictions are placed on the number of allowable inter-educational level transitions. The arrows in Figure 6-4 indicate the permissible transitions. If the probability of transiting from state i to state j in one year is denoted by p_{ij}, then a priori, the following expressions hold:

$$p_{1,7} = p_{1,8} = p_{1,9} = p_{1,10} = p_{1,11} = p_{1,12} = p_{1,13} = 0,$$

$$p_{2,7} = p_{2,8} = p_{2,9} = p_{2,10} = p_{2,11} = p_{2,12} = p_{2,13} = 0, \text{ and}$$

$$p_{6,7} = p_{6,8} = p_{6,9} = p_{6,10} = p_{6,11} = p_{6,12} = p_{6,13} = 0.$$

These three strings of equalities simply state that if a person with an undergraduate degree is not enrolled in school during one year, he cannot have a Master's or Doctorate degree by the following year. Similarly,

$$p_{7,12} = p_{7,13} = 0$$

$$\text{and } p_{11,12} = p_{11,13} = 0$$

which depend upon similar reasoning for people with Master's degrees. Other zero probabilities are those which represent cases in which the educational level of a person in one year is higher than his level in the next year. For these reasons, out of total of 13 x 13 = 169 possible transition probabilities, only 68 are not necessarily zero.

A convenient way of representing these probabilities is through the use of a transition matrix T, of which each entry p_{ij} is the probability of an individual in state i occupying state j one year later. Thus, for each arrow shown in Figure 4, a non-zero probability would appear in the matrix. The development of this matrix for different student and teacher groups is one of the principal model outputs.

The second major concept is that of a <u>state vector</u> which is a 13-dimensional column vector, the k^{th} entry of which denotes the <u>number</u> of individuals of a given group occupying the k^{th} state at a given time.

If V_t = the state vector at year t and T = the transition matrix

then $V_{t+1} = TV_t$

$$V_{t+2} = TV_{t+1} = T^2 V_t$$

and ultimately, $V_{t+n} = T^n V_t$.

(These relationships are elementary consequences of the theory of finite state Markov chains and implicitly assume that the transition probabilities are stationary. That is, that the probabilities p_{ij} are independent of time.) Given an initial state of teachers, it is then possible to determine their state n years later.

SAMPLING METHODOLOGY

Students

The students were to be sampled on the basis of their area of specialization, size of the Special Education department at each university, and level of training during 1968-69. To obtain address information, a list of BEH recipients' names was sent to a sample of colleges and universities receiving BEH program funding. In addition, the colleges and universities were requested to submit lists of names and addresses for non-BEH recipients who were in Special Education training during 1968-69.

A three-by-three matrix for each student group (recipients and non-recipients) was created using three levels of training and three specialty areas[1] as the row and column headings. Based upon enrollment records held by BEH, it was determined that the number of Master's students in training accounted for approximately one and one-half as many students as those in their senior year; in addition, approximately four and one-half times as many Master's students as post-Master's students were in training during 1968-69. The sample was intended to duplicate this distribution. It was also decided to divide the total number of students to be sampled in each specialty area equally among the three educational program levels. This resulted in a sample plan of 125 seniors, 200 Master's, and 45 post-Master's students

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1. The three specialty areas are:

Sensory Disorders	Learning Disorders	Other
Visually Handicapped	Mentally Retarded	Crippled
Deaf - Hard of Hearing	Learning Disability	Other Health Impaired
Speech and Hearing	Emotionally Disturbed	Physically Handicapped
Deaf - Blind		Administration
		Multiple Handicapped
		Other

This categorization is used throughout the remainder of this report.

in each of the three specialty areas. The same plan was applied both to recipients and non-recipients for a total student sample of 2,220.

The total number of students enrolled in the "other" category turned out to be just over 400. After deductions were made for those for whom valid address information was unavailable, this total number was below that called for by the plan. Thus, rather than just sampling students in the "other" category, we resorted to sending questionnaires to all trainees in this area for whom addresses were available--a total of 201, rather than the 370 called for by the original plan. All subsequent results must be interpreted in light of this fact--the sample was not intended to and does not reflect the actual proportions of students in the three specialty areas.

After three waves of mailout, 1,173 usable questionnaires were received, for an overall response rate of 57 percent, distributed as shown in Table 4.

Table 4

DISTRIBUTION OF STUDENT RESPONSES

Specialty Area	Undergraduates		Master's		Post-Master's	
	Recipients	Non-Recipients	Recipients	Non-Recipients	Recipients	Non-Recipients
Sensory Disorders	84	71	127	108	30	27
Learning Disorders	73	67	121	105	35	26
Other Specialties	30	60	104	59	33	13
Total	187	198	352	272	98	66

Teachers

The teacher questionnaire was sent to a sample of 3,750 practicing Special Education teachers in February 1972. After two follow-up waves of mailout, a total of 2,068 responses were obtained for a response rate of 55 percent. The names and addresses of the teachers were drawn from lists provided by state and local education agencies. States were drawn from each OE region so that a total of 26 states were represented. Districts in these states were ranked according to the number of teachers in them, resulting in a sampling fraction for the selection of districts for each state. Sampling fractions were then computed for the teachers, who were selected using random start procedures. This resulted in a set of weights for the teachers used to inflate their responses to the total national teaching population. The weights varied from one (if a teacher was chosen with certainty) to as much as 400. The mean weight of any teacher response was about 55.

Although this procedure was meant to provide a sample that was representative of the national population of practicing Special Education teachers, our inability to obtain complete lists of teachers for sample selection, together with the lack of usable responses from all the selected teachers leaves the possibility of bias in the results. We believe, however, that the weighted responses, if not totally representative of the national population, are at least indicative of it.

DATA GENERATION

Since a special format was developed for generating the model's input data, it is specifically dealt with here. The data on career patterns were obtained from four portions of a student/teacher questionnaire. These were:

- an education section to obtain year of each degree received and nature of full-time/part-time attendance at universities,
- an employment section to determine length of time in jobs and nature of current position,

- the current status to obtain current "in" or "out" status, and
- the incidence of temporary leaving to obtain data on those who temporarily left the field.

In addition, data on the respondents' sex, specialty area, and level of funding (if applicable) were collected.

Using the above data sources, each questionnaire was examined to determine whether a complete picture of the respondent's career was available. This injected a bias into the teacher data base as the employment section obtained data only on the respondent's last four jobs. Thus, the bias is towards younger and/or more stably-employed individuals. For the students, the situation was much simpler since their careers required tracing only since 1968-69. (For 400 of the students, however, complete histories were obtained as well, including prior work and educational experience.) Once it was determined that a complete picture was available, the states were selected that best described the respondent's situation in each year since receiving his undergraduate degree.

Some examples will help illustrate this process:

- A teacher has spent five years teaching since receiving his degree. He would be coded as:

  1 2 2 2 2 2, where

  the "1" indicates receipt of Bachelor's and the five "2's" indicates five years as a practicing teacher with an undergraduate degree (state C2 in Figure 4).

- A teacher spent two years teaching, returned full-time to school for a Master's, taught for two more years, left the field for one year, returned to teach for five years while attending school part-time, obtained his Doctorate and has been in the field for three years. His history would be coded as:

  1 2 2 4 7 7 11 8 8 8 8 8 12 12 12, where

  the "1" indicates receipt of Bachelor's degree,

  the two "2's" indicate teaching two years with an undergraduate degree,

  the "4" indicates full-time towards Master's, the two "7's" indicate in Special Education with Master's,

the "11" indicates out of Special Education with Master's,

the five "8's" indicate in the field with Master's, but part-time attendance at a university, and

the three "12's" indicate in the field with a Doctorate.

- A teacher obtained his degree, was out of the field for 16 years, attended a school part-time for four years, and returned to the field with a Master's for full-time teaching. His pattern would look like:

  1 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 5 5 5 5 7, where

  the "1" indicates receipt of Bachelor's degree,

  the 16 "6's" indicate being out with an undergraduate degree,

  the four "5's" indicate being out with part-time schooling towards a Master's, and

  the "7" indicates full-time in the field with a Master's.

These three examples are intended to explain how the histories were encoded for input into the model. In subsequent analyses, reference to the student or teacher's state will be made. When such a statement is encountered, recall that the states are those shown in Figure 4 and that they represent career histories as shown in the above examples.

The results of a non-respondent analyses indicate that there is no substantial difference in the current states of the respondents and non-respondents. Although more of the non-respondents were found to be out of the field, the probability values displayed in the remaining portions of the study are not representative. As a final note, the results shown are actual computer printouts. They contain the probabilities to four decimal places. This precision is clearly not meant to be the case, and most of the values have standard deviations of .05 or higher due to the sample sizes (in most cases under 100).

RESULTS: VERSION I (STATE PROBABILITIES)

A matrix T was computed for different student and teacher cohorts, depending upon sex, educational level attained, type of funding received, and specialty area. The specific groupings chosen for the student tables were dictated by the requirement that the number of questionnaire responses generating data for the calculations was at least ten. They are shown in Table 5. At the undergraduate level, there was no distinction by sex, as the male percent was so small. At the post-Master's level the distinction by specialty group was sacrificed and runs were made by sex. The teacher matrices, on the other hand, were prepared for each of the six combinations of sex and specialty grouping.

Interpreting the Tables

To illustrate how these results are to be interpreted, attention is called to Figures 5, 6 and 7, pertaining to female teachers specializing in sensory disorders.[1] Figure 5 shows that after receiving their Bachelor's degree (state C1)[2],

- .4574 of the graduates became full-time teachers (C1 → C2),
- .1628 of the graduates became full-time teachers but with part-time attendance at a school or university (C1 → C3),
- .2093 of the graduates went on directly to full-time training for a Master's degree (C1 → C4),
- .0078 of the graduates did not enter the field of Special Education but went to school part-time (C1 → C5),
- .1628 of the graduates left the field and were not attending a school or university in the next year (C1 → C6),
- .8667 remained in that status in year t + 1 (C2 → C2),
- .1043 began part-time training in year t + 1 (C2 → C3),

---

1. These examples use only this combination of female teachers in the specialty group of Sensory Disorders. The complete set of results is included in the final report.

2. The notation C1, C2, C3, etc., refer to the states as shown in Figure 4.

Table 5

COMBINATIONS OF TYPE OF FUNDING SUPPORT, SEX, LEVEL, AND SPECIALTY GROUP USED FOR DEVELOPMENT OF STUDENT TRANSITION PROBABILITY MATRICES

<table>
<tr><th rowspan="3">Type of Funding Support / Level and Specialty Group / Sex</th><th colspan="2" rowspan="2">BEH Fellowship Recipients</th><th colspan="6">Non-Recipients</th></tr>
<tr><th colspan="2">Other Source</th><th colspan="2">No Source</th><th colspan="2">Unknown Source[3]</th></tr>
<tr><th>M</th><th>F</th><th>M</th><th>F</th><th>M</th><th>F</th><th>M</th><th>F</th></tr>
<tr><td>Undergraduate</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sensory Disorders</td><td colspan="2">67[1]</td><td colspan="2">26</td><td colspan="2">36</td><td></td><td></td></tr>
<tr><td>Learning Disorders</td><td colspan="2">78</td><td colspan="2">31</td><td colspan="2">40</td><td></td><td></td></tr>
<tr><td>Other</td><td colspan="2">32</td><td colspan="2">18</td><td colspan="2">13</td><td></td><td></td></tr>
<tr><td>Master's</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sensory Disorders</td><td>11</td><td>104</td><td>13</td><td>55</td><td colspan="2">10</td><td></td><td></td></tr>
<tr><td>Learning Disorders</td><td>17</td><td>120</td><td>13</td><td>31</td><td colspan="2">25</td><td></td><td></td></tr>
<tr><td>Other</td><td>13</td><td>52</td><td>14</td><td>12</td><td colspan="2">11</td><td></td><td></td></tr>
<tr><td>Post-Master's</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sensory Disorders</td><td rowspan="3">62</td><td rowspan="3">21</td><td rowspan="3">26</td><td rowspan="3">15</td><td colspan="2" rowspan="3">2</td><td></td><td></td></tr>
<tr><td>Learning Disorders</td><td></td><td></td></tr>
<tr><td>Other</td><td></td><td></td></tr>
</table>

1. The numbers in the ovals indicate the sample size for the combination.
2. No matrices made, sample included only four observations.
3. No matrices were made for those with unknown funding.

MATRIX OF FREQUENCIES

State[1] in Time Period t + 1

State in Time Period t	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12	C13
C01	0.0	0.4574	0.1628	0.2093	0.0078	0.1628	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C02	0.0	0.8667	0.1043	0.0222	0.0	0.0029	0.0029	0.0	0.0	0.0	0.0	0.0	0.0
C03	0.0	0.1837	0.6667	0.0	0.0068	0.0136	0.1293	0.0	0.0	0.0	0.0	0.0	0.0
C04	0.0	0.0377	0.0377	0.3208	0.0	0.0189	0.4340	0.0189	0.0566	0.0	0.0755	0.0	0.0
C05	0.0	0.0909	0.1364	0.0	0.5455	0.0	0.0	0.0455	0.0	0.0	0.1818	0.0	0.0
C06	0.0	0.0316	0.0380	0.0253	0.0506	0.8544	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C07	0.0	0.0	0.0	0.0	0.0	0.0	0.9372	0.0493	0.0	0.0	0.0125	0.0	0.0
C08	0.0	0.0	0.0	0.0	0.0	0.0	0.5455	0.4545	0.0	0.0	0.0	0.0	0.0
C09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0909	0.7273	0.0	0.0909	0.0909	0.0
C10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5000	0.5000	0.0	0.0	0.0	0.0
C11	0.0	0.0	0.0	0.0	0.0	0.0	0.1481	0.0	0.0	0.0370	0.8148	0.0	0.0
C12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0000	0.0
C13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 5: TRANSITION PROBABILITY MATRIX FOR THE 13 MODEL STATES FOR FEMALE, SENSORY DISORDER TEACHERS

1. The state codes are the same as those shown in Figure 4.

MATRIX OF STATES

State in Time Period t+1

State in Time Period t

	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12	C13
C01	0	58	21	27	1	21	0	0	0	0	0	0	0
C02	0	299	36	8	0	1	1	0	0	0	0	0	0
C03	0	27	96	0	1	2	19	0	0	0	0	0	0
C04	0	2	2	17	0	1	23	1	3	0	4	0	0
C05	0	2	3	0	12	0	0	1	0	0	4	0	0
C06	0	5	6	4	8	135	0	0	0	0	0	0	0
C07	0	0	0	0	0	0	299	11	0	0	3	0	0
C08	0	0	0	0	0	0	12	10	0	0	0	0	0
C09	0	0	0	0	0	0	0	1	8	0	1	1	0
C10	0	0	0	0	0	0	0	1	1	0	0	0	0
C11	0	0	0	0	0	0	3	0	0	2	44	0	0
C12	0	0	0	0	0	0	0	0	0	0	0	8	0
C13	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 6: SUPPORTIVE DATA FOR THE TRANSITION PROBABILITY MATRIX FOR FEMALE, SENSORY DISORDER TEACHERS

.0232 began a full-time Master's program in year t + 1 (C2 ⟶ C4),

none left the field with part-time attendance at a university (C2 ⟶ C5), and

.0029 left the field in year t + 1 (C2 ⟶ C6).

For each row, similar results can be obtained from Figure 5.

Figure 5 was developed from counts of all cases in which teachers were found to be in one of the 13 possible model states. The sample size decreases with educational level achieved--since only about 45 percent of these teachers have an advanced degree. Figure 6 shows the supportive base for Figure 5. All 128 teachers are in the data base for the transition from state C1 to states C2 through C6.

The final portion of this example concerns the vector of current states. This vector is shown in Figure 7. Of the 128 teachers, 48 are currently teaching full-time with an undergraduate degree only; 49 are teaching with a Master's, and one has obtained her Doctorate and is in the field. Four are currently in school full-time (states C4 and C9), and 4 have left the field (states C6, C11, and C13). Twenty-one are undertaking part-time training while teaching full-time (states C3 and C8). Recalling that states C2, C3, C7, C8, and C12 comprise the pool of practicing Special Education teachers, the size of this pool is 120.

RESULTS: VERSION II (INCORPORATING TIME IN STATE)

The computation of the transition matrix has been seen to depend only upon whether an individual enters or leaves a specific state. The time that he spends occupying the state does not influence the calculations. A second version of the manpower model relies upon the explicit incorporation of the length of time an individual occupies a given state.

For this version, the analogue of the previous transition matrix is a transition matrix where rows and columns denote the length of time "in" or "out" of Special Education positions. The "in Special Education" states (C2, C3, C7, C8, and C12) were combined as were the five "out of Special Education" states (C5, C6, C10, C11, and C13). This was done to keep the matrix to manageable proportions, consistent with the size of the data base. Training was also considered as one state--regardless of whether it was the Master's or post-Master's level. The matrices were developed for the groups as previously identified.

Interpreting the Tables

Figure 8 shows the specific transition probabilities after being in Special Education for 1, 2, 3, 4-5, 6-10, 11-15, 16-20, 21-30, 31-40, and over 40 years for the same female, sensory disorder group as above. For being out of the field, the time intervals are similar. Thus:

.9537 of the teachers who have taught for one year continue teaching for the next year (SP ED ⟶ SP 2),

.0185 of the teachers who have taught for one year enter full-time training (SP ED ⟶ TRAIN), and

.0278 of them leave the field (SP ED ⟶ OUT 1).

After teaching for three years the comparable values are .9841, .00, and .0159, respectively. These values are obtained by reading horizontally across the rows. By reading down the left-hand stub to the state of interest, the subsequent movement of the teacher can be followed. Thus, this output allows for the tracing of patterns if desired. Examination of the column headed SP ED (first year as a Special Education teacher) shows the rate of flow of those who were out of the field (either in training or not) and back into their first year of teaching. In this instance, the rates are relatively constant (.09, .14, .11, .12) for the first four years that a teacher is out of the field without ever having taught.

Figure 9 shows the backup data for Figure 8. It is analogous to Figure 6 discussed above.

There is also a vector of current states for this output version. It is shown in Figure 10. It shows the current state and for what length of time the respondent has been in that state for each of the 128 respondents. The numbers match those

MATRIX OF FREQUENCIES

State in Time Period t + 1

State in Time Period t

	BA	SP ED	SP2	SP3	SP4-5	SP6-10	SP11-15	SP15-20	SP20-30	SP30-40	SP40+	TRAIN	OUT
BA	0.0078	0.6202	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2093	0.0
SP ED	0.0	0.0	0.9537	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0185	0.0
SP2	0.0	0.0	0.0	0.9647	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0118	0.0
SP3	0.0	0.0	0.0	0.0	0.9841	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SP4-5	0.0	0.0	0.0	0.0	0.5288	0.4615	0.0	0.0	0.0	0.0	0.0	0.0096	0.0
SP6-10	0.0	0.0	0.0	0.0	0.0	0.8333	0.1609	0.0	0.0	0.0	0.0	0.0057	0.0
SP11-15	0.0	0.0	0.0	0.0	0.0	0.0	0.5288	0.1532	0.0	0.0	0.0	0.0090	0.0
SP15-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8113	0.1698	0.0	0.0	0.0189	0.0
SP20-30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9565	0.0217	0.0	0.0217	0.0
SP30-40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0000	0.0	0.0	0.0
SP40+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRAIN	0.0	0.3750	0.0156	0.0156	0.0156	0.0	0.0156	0.0156	0.0156	0.0	0.0	0.4375	0.0
OUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OUT1	0.0	0.0926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0313	0.0
OUT2	0.0	0.1429	0.0714	0.0357	0.0357	0.0	0.0	0.0	0.0	0.0	0.0	0.0357	0.0
OUT3	0.0	0.1053	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OUT4	0.0	0.1176	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OUT5	0.0	0.0667	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OUT6-10	0.0	0.0492	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OUT11-15	0.0	0.1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0500	0.0
OUT16-20	0.0	0.1429	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OUT21-25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1429	0.0
OUT25+	0.0	0.3333	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	OUT	OUT1	OUT2	OUT3	OUT4	OUT5	OUT6-10	OUT11-15	OUT16-20	OUT21-25	OUT25+
BA	0.0	0.1705	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SP ED	0.0	0.0278	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SP2	0.0	0.0235	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SP3	0.0	0.0159	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SP4-5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SP6-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SP11-15	0.0	0.0090	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SP15-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SP20-30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SP30-40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SP40+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRAIN	0.0	0.0938	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OUT1	0.0	0.0	0.5750	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OUT2	0.0	0.0	0.0	0.6786	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OUT3	0.0	0.0	0.0	0.0	0.5947	0.0	0.0	0.0	0.0	0.0	0.0
OUT4	0.0	0.0	0.0	0.0	0.0	0.8824	0.0	0.0	0.0	0.0	0.0
OUT5	0.0	0.0	0.0	0.0	0.0	0.0	0.9333	0.0	0.0	0.0	0.0
OUT6-10	0.0	0.0	0.0	0.0	0.0	0.0	0.7869	0.1639	0.0	0.0	0.0
OUT11-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7500	0.1000	0.0	0.0
OUT16-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7143	0.1429	0.0
OUT21-25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7143	0.1429
OUT25+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6667

Figure 8: TRANSITION PROBABILITY MATRIX, BY LENGTH OF TIME IN STATE FOR FEMALE SENSORY DISORDER TEACHERS

MATRIX OF STATES

State in Time Period t+1

	BA	SP ED	SP2	SP3	SP4-5	SP6-10	SP11-15	SP15-20	SP20-30	SP30-40	SP40+	TRAIN	OUT
BA	0	79	0	0	0	0	0	0	0	0	0	27	0
SP ED	0	4	103	0	0	0	0	0	0	0	0	2	0
SP2	0	0	0	82	0	0	0	0	0	0	0	1	0
SP3	0	0	0	0	62	0	0	0	0	0	0	0	0
SP4-5	0	0	0	0	55	48	0	0	0	0	0	1	0
SP6-10	0	0	0	0	0	145	23	0	0	0	0	1	0
SP11-15	0	0	0	0	0	0	92	17	0	0	0	1	0
SP15-20	0	0	0	0	0	0	0	43	9	0	0	1	0
SP20-30	0	0	0	0	0	0	0	0	44	1	0	1	0
SP30-40	0	0	0	0	0	0	0	0	0	1	0	0	0
SP40+	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAIN	0	24	1	1	1	0	1	1	1	0	0	28	0
OUT	0	0	0	0	0	0	0	0	0	0	0	0	0
OUT1	0	3	0	0	0	0	0	0	0	0	0	1	0
OUT2	0	4	2	1	1	0	0	0	0	0	0	1	0
OUT3	0	2	0	0	0	0	0	0	0	0	0	0	0
OUT4	0	2	0	0	0	0	0	0	0	0	0	0	0
OUT5	0	1	0	0	0	0	0	0	0	0	0	0	0
OUT6-10	0	3	0	0	0	0	0	0	0	0	0	0	0
OUT11-15	0	4	0	0	0	0	0	0	0	0	0	2	0
OUT16-20	0	2	0	0	0	0	0	0	0	0	0	0	0
OUT21-25	0	0	0	0	0	0	0	0	0	0	0	1	0
OUT25+	0	1	0	0	0	0	0	0	0	0	0	0	0

	OUT	OUT1	OUT2	OUT3	OUT4	OUT5	OUT6-10	OUT11-15	OUT16-20	OUT21-25	OUT25+
BA	0	22	0	0	0	0	0	0	0	0	0
SP ED	0	3	0	0	0	0	0	0	0	0	0
SP2	0	2	0	0	0	0	0	0	0	0	0
SP3	0	1	0	0	0	0	0	0	0	0	0
SP4-5	0	0	0	0	0	0	0	0	0	0	0
SP6-10	0	0	0	0	0	0	0	0	0	0	0
SP11-15	0	1	0	0	0	0	0	0	0	0	0
SP15-20	0	0	0	0	0	0	0	0	0	0	0
SP20-30	0	0	0	0	0	0	0	0	0	0	0
SP30-40	0	0	0	0	0	0	0	0	0	0	0
SP40+	0	0	0	0	0	0	0	0	0	0	0
TRAIN	0	6	0	0	0	0	0	0	0	0	0
OUT	0	0	0	0	0	0	0	0	0	0	0
OUT1	0	0	23	0	0	0	0	0	0	0	0
OUT2	0	0	0	19	0	0	0	0	0	0	0
OUT3	0	0	0	0	17	0	0	0	0	0	0
OUT4	0	0	0	0	0	15	0	0	0	0	0
OUT5	0	0	0	0	0	0	14	0	0	0	0
OUT6-10	0	0	0	0	0	0	48	10	0	0	0
OUT11-15	0	0	0	0	0	0	0	30	4	0	0
OUT16-20	0	0	0	0	0	0	0	0	10	2	0
OUT21-25	0	0	0	0	0	0	0	0	0	5	1
OUT25+	0	0	0	0	0	0	0	0	0	0	2

Figure 9: SUPPLEMENTARY DATA FOR TRANSITION PROBABILITY MATRIX, BY LENGTH OF TIME IN STATE FOR FEMALE SENSORY DISORDER TEACHERS

VECTOR OF CURRENT STATES

BA	0
SP ED	17
SP2	21
SP3	21
SP4-5	15
SP6-10	19
SP11-15	10
SP15-20	8
SP20-30	8
SP30-40	1
SP40+	0
TRAIN	4
OUT	0
OUT1	3
OUT2	0
OUT3	0
OUT4	0
OUT5	0
OUT6-10	1
OUT11-15	0
OUT16-20	0
OUT21-25	0
OUT25+	0

Figure 10: VECTOR OF CURRENT STATES FOR FEMALE SENSORY DISORDER TEACHERS

of Figure 7, with four teachers being in full-time training and four currently being out.

MODEL OPERATIONS--EXAMPLES

The transition probability matrices T, developed and shown earlier (Figures 5 and 8) and the vectors of current state (Figures 7 and 10) serve as the major inputs into the model's use as an analytic tool. While they themselves were generated by the model's calculations on the string of successive states obtained for each respondent from the questionnaires, much can be accomplished by administrators using these matrices and vectors as raw material.

For the sample sizes indicated in Figure 4, two types of matrices and two types of vectors of current state were produced. Thus, policy makers have the transition probabilities for those cohorts according to the 13 model states and with regard to length of time in selected states. By multiplying the vector of current states by its comparison transition probability matrix, a projection of the vector of current states for the next year can be made. By altering one or more of the probabilities in the matrix, the estimates of what might happen if things were different can be made. This section will show how an analyst can use the detailed tables to assess alternative strategies.

An Example of Projecting the Current States Ahead for a Year

Using the same set of female sensory disorder teachers displayed in Figures 5 through 10, an example of projecting the size of the pool of those teachers in the next year will be explained. The operation to be undertaken is quite simple mathematically--multiplying the matrix T by the vector V_t to get V_{t+1}. However, the problem is somewhat tedious as several multiplications are required. Indeed, 13 x 13 calculations are needed (although some of them are easily done as one of the multipliers is zero). Using Figures 5 and 7 for this example, Figure 5 is the transition probability matrix, T, and Figure 7 is the vector of current states, V. To project ahead to the next year, each element in the vector V must be multiplied by the relevant transition probabilities. Specifically, the process begins by taking the 48 teachers who are in state C2 (from Figure 7) in year t (the current year) and multiplying this value by the transition probabilities from Figure 5 that correspond to what those in state C2 will do in the next time period. Thus:

.8667 of them will remain in state C2,

.1043 of them will move to state C3,

.0232 of them will move to state C4,

.0029 of them will move to state C6, and

none of them will move to states C1, C5, C7 through C13.

Multiplying these probabilities by the number of persons in state C2 (48), we calculate that of the 48 in state C2 in time period t, there are

41.60 remaining in state C2

5.15 moving to state C3

1.11 moving to state C4, and

.14 moving to state C6 in time period t+1.

These calculations are made for the remaining 11 states in the vector of current states (Figure 7). Once done, it is only necessary to add up the persons in each state to obtain the new current state vector. For example, with regard to state C2 in year t+1, 41.60 came from state C2, 3.48 from state C3, .11 from state C4 and .06 from state C6 meaning that there will be 45.25 teachers in state C2 in year t+1.

These calculations were made for all 13 states to produce the following vector of current states for year t+1 as shown in Figure 11. The changes in this vector are not striking, but they show that, based upon the 128 teachers in this sample, the number of teachers out of the field increased from 4 to 5.08,

Vector of Current States (year t+1)	
C 1	0
C 2	45.25
C 3	18.01
C 4	2.12
C 5	.23
C 6	3.17
C 7	51.62
C 8	3.93
C 9	.90
C10	.07
C11	2.61
C12	1.09
C13	0

Figure 11: VECTOR OF CURRENT STATES FOR FEMALE SENSORY DISORDER TEACHERS IN YEAR t+1

that the number of teachers with an undergraduate degree only fell from 72 to 67.78 and that the number of practicing teachers with a Master's increased from 52 to 55.55.

The vector of current states shown in Figure 11 refers to the cohort of 128 teachers sampled for the analysis. Thus, there are no additional teachers entering this cohort via state C1 (receipt of undergraduate degree). If a federal or state administrator wished to project the entire pool of these teachers, then an estimate of how many new undergraduates in this cohort (sensory disorder) would be produced for year t. On the assumption that this value would be 10, then the vector of current states (Figure 7) would be altered to reflect the 10 graduates in state C1. Then, in order to prepare the new vector of current states (Figure 11) these 10 new teachers could be multiplied by the transition probabilities from state C1 to other states. When this was accomplished, the new vector of current states--reflecting all 128 female sensory disorder teachers was produced--see Figure 12. As can be seen, each of

VECTOR OF CURRENT STATES (t+1) with 10 additional undergraduates)	
C 1	0
C 2	49.82
C 3	19.64
C 4	4.21
C 5	.30
C 6	3.80
C 7	51.62
C 8	3.93
C 9	.90
C10	.07
C11	2.61
C12	1.09
C13	0

Figure 12: VECTOR OF CURRENT STATES FOR FEMALE SENSORY DISORDER TEACHERS IN YEAR t+1 WITH 10 ADDITIONAL UNDERGRADUATES

the states C2 through C6 have been affected by these graduates; almost half of them went to state C2, while the others were distributed about evenly to states C3, C4, and C6.

Such analyses could be continued for several years into the future recalling the basic assumption that the rates of moving from one state to another are independent of time. Projections of the size of the pool can be made to reflect several assumptions with regard to the number of graduates (at any level) that BEH can help produce. If, for instance, it is hoped to bring the 10 additional graduates used in the above example into the field, then these policies increased the pool by 6.2 teachers.

Analyses based on the changes in the transition probabilities similar to the example described earlier can be done on the values shown in Figures 5 and 7. Again, we can hypothesize that some policy would reduce the rate of teachers leaving by 50 percent. Thus, the transition probability of moving from state C2 to state C6 would drop from .0029 to .0014, as an example. If these values are changed, a new vector of current states can be calculated. This was done and it is shown in Figure 13. As can be seen the number of teachers out of the field falls only slightly, from 5.08 to 4.42; thus, the pool is increased by only .66 teachers.

VECTOR OF CURRENT STATES (Year t+1, with halved leaving probabilities)	
C 1	0
C 2	45.32
C 3	18.21
C 4	2.15
C 5	.17
C 6	1.94
C 7	51.95
C 8	3.93
C 9	.95
C10	.07
C11	2.24
C12	1.09
C13	0

Figure 13: VECTOR OF CURRENT STATES FOR FEMALE SENSORY DISORDER TEACHERS IN YEAR t+1, HALVED RATES OF LEAVING THE FIELD

Since the costs of producing these two changes (the 10 extra teachers and halving the rates of leaving) are not currently assembled, a determination of which is the most cost-effective cannot be made. However, it can be seen that relatively large changes in the rates of leaving do not markedly affect the size of the pool. Indeed, if the rates of leaving became zero, the increase in the pool would have only been 1.32 for this one-year period.

Summary

This paper has tried to show how the manpower model can be used by federal and state policy makers to assess the outcome of proposed strategies. RMC has used such manipulations to assist in its analysis of alternative strategies.