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ABSTRACT

This report examines the logic that underlies projection methods and applies that logic to data describing vocational teacher needs for 1978 through 1982. (The report addresses the demand for vocational education teachers only, not for other personnel such as counselors, prevocational teachers, and so on.) The report is organized into three sections. The first section contains a description of the techniques used to examine the past and to project the future demand for vocational teachers. In the second section, a critical assessment is made of the methods and data used to generate the projections for enrollments and teachers. The third section contains a brief analysis of the kinds of activities that, when carried out, would improve the adequacy and accuracy of the projection statistics. (The analysis concerns demand for teachers only and does not address the philosophy of teacher needs.) (KC)

PROJECTIONS OF DEMAND FOR VOCATIONAL TEACHERS, 1978-1982

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FOREWORD

Teachers are a major component of the vocational education delivery system. Planning and policy development to provide for the number of teachers required is critical to the future success of vocational education programs. Data on future demand for teachers are necessary to these planning and policy efforts. The National Center, under its contract with the Bureau of Occupational and Adult Education, U.S. Office of Education is pleased to have assisted in our examination of such data by developing this report. The authors of Projections of Demand for Vocational Teachers, 1978-1982 examine the logic which underlies projection methods and apply that logic to data describing vocational programs for 1978 through 1982.

Efforts to project future conditions are generally less than exact, depending on assumptions about future behavior and reliable historical or trend data. In the course of analyzing trends in teacher demand, the authors did not collect any new data, using instead information from the five-year state plans describing enrollments.

The authors find a need for quality data describing vocational education. As fundamental improvements are realized in the quality of data, policy and planning will be better able to benefit from the knowledge developed from analyses like the present one.

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INTRODUCTION

The United States' publicly supported system of vocational education includes instructional programs in many agencies including secondary school districts, area vocational schools, community and junior colleges and other postsecondary institutions. Enrollments in the eight program areas have increased from 9 million in 1971 to 14 million in 1978. The number of teachers increased from 197,000 in 1971 to 299,000 in 1978. The provision of quality instruction to all vocational students requires an adequate teaching staff now. With the rapid growth in vocational enrollments, there is a legitimate concern over the future demand for and supply of qualified vocational teachers.

The level of demand for teachers should be anticipated early, in order that the supply of qualified teachers can be assured for future instructional programs. The Education Amendments of 1976 (P.L. 94-482) address this matter by requiring that the U.S. Commissioner of Education for each fiscal year, ". . .publish a listing of the areas of teaching in vocational education which are presently in need of additional personnel in the future."

The purpose of this report is to provide the best available information which is necessary to produce a listing of teaching areas which need additional personnel, as called for in the Education Amendments of 1976. The report addresses the demand for vocational education teachers, as intended by the legislation, and does not address demand for such other personnel as counselors, administrators, planners, evaluators, curriculum specialists or prevocational teachers.

This report is organized into three sections. The first contains a description of the techniques used to examine the past and to project the future demand for vocational teachers. The second contains a critical assessment of the methods and data used to generate the projections for enrollments and teachers. The third section contains a brief analysis of the kinds of activities which, when carried out, would improve the adequacy and accuracy of the projection statistics.

There continues to be a need for additional teachers in all vocational areas. Some, if not all, of the teachers who leave their jobs would have to be replaced. The need for teachers might be defined as that number an administrator wants to hire. It might be defined as the number required for an ideal educational system or it might be defined as the difference between the number of budgeted positions and the number of applicants, if there is a shortage.

At best then, policy judgments as to the need for teachers can be informed by an assessment of the demand for and supply of vocational teachers and from an intelligent assessment of a given labor market. The concept of need involves how many and what type of teachers should be budgeted, and there are many different points of view about need. We restrict our analysis to that of demand.

CONCEPTUALIZING AND MEASURING THE DEMAND FOR VOCATIONAL TEACHERS

There are two concepts which are useful for analyzing the demand for teachers: the total demand and the total additional demand. The total demand for teachers in a given year has both statistical and practical definitions. Statistically, the total demand for teachers in the enrollment divided by student-teacher ratio:

$$\text{TOTAL DEMAND} = \frac{\text{ENROLLMENT}}{\text{STUDENT-TEACHER RATIO}}$$

or

$$T = \frac{E}{R}$$

Practically speaking, the total demand for teachers is the number of budgeted positions of teaching staff, which may be expressed in full time equivalents. Both the enrollment and a desired student-teacher ratio should influence the practical demand for teachers. However, budgetary considerations also have a large effect on the "desired" student-teacher ratio and possibly a constraint on enrollments.

The concept of total additional demand is needed when projecting enrollments and staffing from one year to the next or when budgeting and hiring for a subsequent year. The concept of total additional demand is defined as the difference in demand for teachers due to changes in enrollment, changes in the student-teacher ratio, and turnover among the present stock of teachers. Thus, from one year to the next enrollments may change, changing the demand for teachers. Administrative decisions may affect permissible student-teacher ratios. Also, teachers who retire, quit, or otherwise leave a school may have to be replaced. Together these three components define the total additional demand, with the following formulas:

Let TA_t = Total Additional Demand in year t.

DR = Additional Demand due to student-teacher ratio changes

DE = Additional Demand due to enrollment changes

A = The attrition rate, or the proportion of teachers who must be replaced

then $TA_t = DR + DE + AT_{t-1}$

$$DR_t = \frac{E_t}{R_t} - \frac{E_t}{R_{t-1}}$$

$$DE_t = \frac{E_t - E_{t-1}}{E_{t-1}} * T_{t-1} = \frac{E_t - E_{t-1}}{R_{t-1}}$$

Total additional demand (TA) consists of three parts: (1) DE, that additional demand due only to changes in enrollment, which is directly proportional to the percentage change in enrollment, (2) DR, that additional demand due to changes in the student-teacher ratio, and (3) $A(T_{t-1})$, the proportion of last years teachers who, for one reason or another, are not available for teaching in the current year.

Before examining the behavior of these equations, a few issues in developing appropriate measures for each component should be considered. Changes in enrollment and attrition of teachers can be measured with precision. Inadequacies in the data describing enrollments or their projections would pose serious problems for the analysis of teacher demand. Practically, very little is known about the attrition rates of teachers, and assumptions generally have to be made about an appropriate rate.

Theoretically, the student-teacher ratio is not so easy to specify. Arguments abound as to the "appropriate" ratio for classroom instruction, and any discussion of the appropriate ratio is certain to generate heated debate. Practically, the observed ratio of students to teachers is typically used. The statistical solution to the problem of an appropriate ratio will tend to generate estimates of demand for teachers in response to the process of administrative control of the educational system. For example, a political decision could be made to reduce the ratio and a substantial increase in the actual demand for teachers would appear, although no changes in enrollment or turnover occurred. Thus, the use of observed values of a student-

teacher ratio to project future demand cannot and will not reflect policy changes in educational administration. Projections are limited in their application for this reason.

Care should be taken in the interpretation and application of estimates of teacher demand. Not only is the student-teacher ratio easily manipulated and subject to direct administrative control, but as we shall see, the demand for teachers is extremely sensitive to slight changes in the ratio.

The three components of teacher demand do not have the same strength of influence on total demand. Consider the basic equation for teacher demand, $T = \frac{E}{R}$. If E should increase by some factor, say x, what is the effect on T? Let T' represent the new demand for teachers,

$$T = \frac{E}{R}$$

$$T' = (1 + x)\frac{E}{R}$$

$$T' = (1 + x)\ T$$

Thus, when E the enrollment, increases .32 of its existing level, the total demand for teachers will increase by .32 of its existing level and will equal 1.32 times its former level.

What happens to teacher demand when the student-teacher ratio decreases by x? (Note: a decrease in the ratio produces an increase in demand)

$$T = \frac{E}{R}$$

$$T' = \frac{E}{R - xR} = \frac{1}{1 - x} \cdot \frac{E}{R}$$

$$T' = \frac{1}{1 - x}\ T$$

Thus, when R, the student-teacher ratio, decreases by .32 of its existing level, the total demand for teachers will increase by a factor of $(\frac{1}{1 - .32})$ from its existing level and will equal 1.47 times its former level.

What happens to teacher demand when there is attrition? Nothing happens to total demand since $T = \frac{E}{R}$. However, total additional demand (TA) will increase by the same percentage

of teachers who are not available for teaching. Turnover of teachers entails certain activities to replace them; such replacement activity only restores the level of teachers to its equilibrium point.

Let's examine the implications of teacher turnover. Does the difference in teacher demand between any two years equal the total additional demand? No, as the following equations demonstrate.

$$DT = T_t - T_{t-1} = DE_t + DR_t$$

$$TA_t = DE_t + DR_t + AT_{t-1}$$

$$DT \neq TA_t$$

The effects of each factor on total teacher demand are compared in Figure 1, which contains a curve for enrollment change, ratio change, and attrition. The horizontal axis represents a proportional change in each of the three factors. The vertical axis represents the resulting change in total additional demand.

For enrollment, an increase of 50% will produce a 50% increase in the demand for teachers. An attrition rate of 50% will require replacing or hiring 50% of the existing staff. However, a 50% reduction in the student-teacher ratio will produce a 200% increase in the demand for teachers.

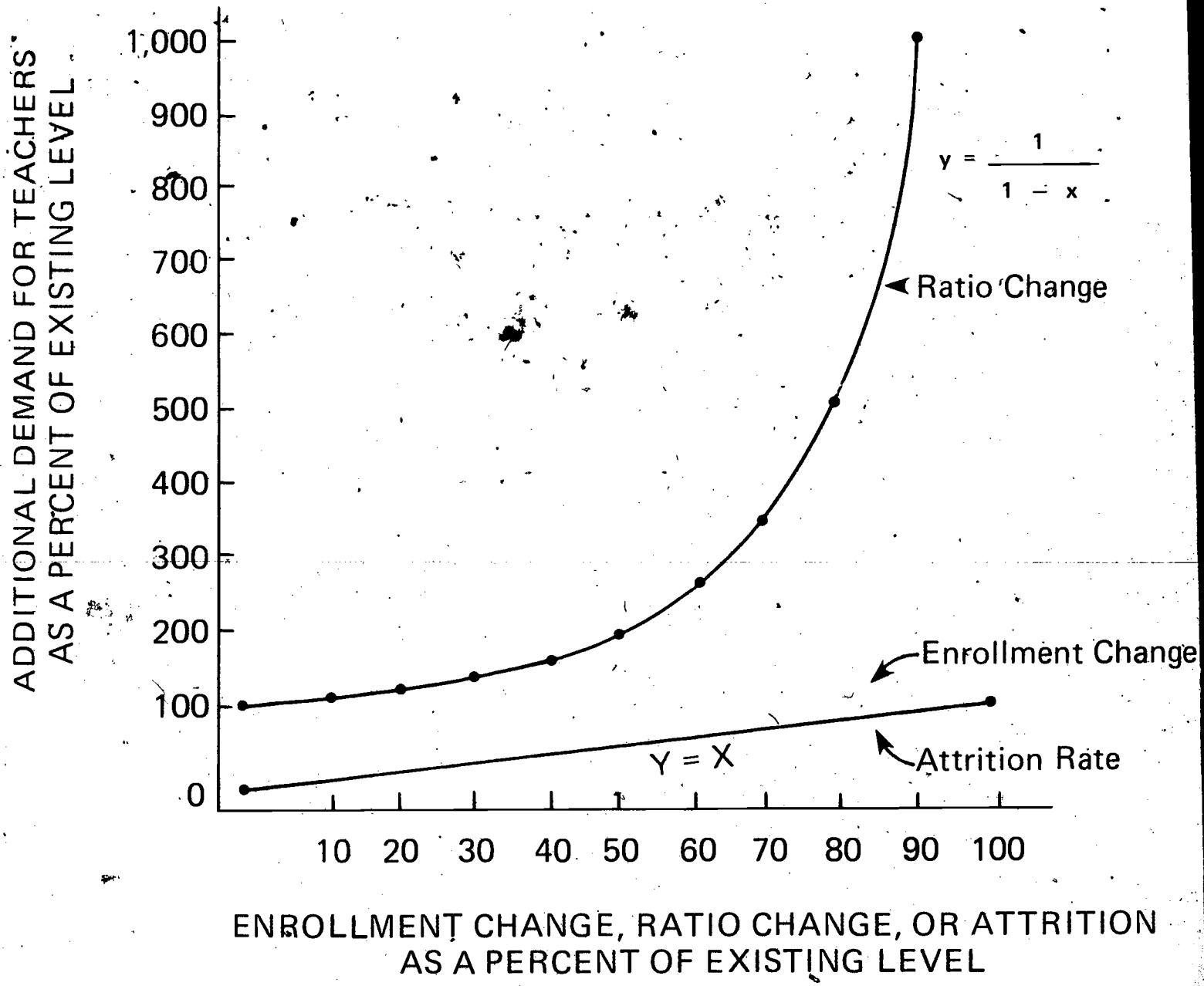
In a fairly stable system, fluctuations in the student-teacher ratio will be minor. Generally, enrollment changes and attrition account for the bulk of the additional demand for teachers. A political decision to change the ratio on a system, however, would have a very significant, yet undetected, change on the actual demand for teachers. Therefore, interpretations of demand statistics should be tempered accordingly.

Limitations and Difficulties in Developing Actual Projections

The analysis of trends and the projection of future demands require quality data describing those past trends and methods for estimating future events. Each of the three components of total additional demand has unique features which must be understood and considered when using or developing projection statistics. These unique features are examined here.

FIGURE 1

SENSITIVITY OF TEACHER DEMAND TO ITS THREE DETERMINANTS



Enrollment data and projections. In the previous pages, changes in the student-teacher ratio were observed to have the largest potential effect on changing the demand for teachers. Yet, the number of students enrolled and the projection of future enrollments constitute the key elements in projecting teacher demand. In particular, it is the projected enrollment which must be carefully developed. Administrators tend to respond to changes in enrollment by hiring, or discharging teachers, or altering the student-teacher ratio. The number of students requiring instruction cannot be so manipulated: it is a given and the educational system responds to it. Enrollment projections are fundamental to all other kinds of educational projections. A serious flaw in the projections of enrollment renders other projections of little value.

Enrollment trends can be established and analyzed by using data from a rigorous collection system. Enrollment projections must be forecast into the future, and hence require special techniques and reliable data. Several general techniques exist. The National Center for Education Statistics (NCES) has developed good techniques for projecting educational statistics for general education. They start with population projections and use different assumptions about female fertility to estimate the expected number of children. Once the number of young entrants is known, or estimated, the retention rate at each grade is applied to the population estimate to yield an expected number of students remaining in school through the twelfth grade.

With adequate data to project populations and to compute trends in grade-retention rates, very reliable enrollment projections may be made. One year projections made by NCES since 1966 have been accurate on the average of 0.2% of actual enrollments; five year projections have been accurate to 1.1%; ten year projections have been accurate to 3.4%.

To develop estimates of vocational enrollments, two alternatives exist. First, the reliable projections of secondary school enrollments could be used to define the population from which vocational enrollments are drawn. Then the trend for vocational enrollments as a percentage of total enrollments could be projected. Similar projections for postsecondary and adult enrollments could be developed. The development of enrollment projections using this first alternative is complicated and requires reliable data for vocational enrollment at secondary, postsecondary, and adult levels.

The second source of projections of vocational enrollments, and the one employed here, is the state plans for vocational education. These plans contain five years of projected enrollments developed by each state. A priori, there is little

information as to the reliability of these projected enrollments. As we will see shortly, there is reason to question the reliability of the enrollment data from the state plans for projecting teacher demand. Nonetheless, the state plan data exist and their use vastly simplifies the problem of developing enrollment projections.

Student-teacher ratio. The student-teacher ratio is a policy variable in the strict sense. The ratio can be changed through direct administrative procedures. The ratio can be decreased to absorb "surplus" teachers, or can be increased with a shortage in the supply of teachers. There is no way to establish the proper ratio, and the use of any particular ratio should not be construed in any way save for statistical convenience.

In this report, the ratio used is the one from the last year for which data are available. The ratio could also be projected assuming a continuation of past trends.

Teacher attrition. The number of teachers who must be replaced from year to year has been the most difficult component of total additional demand to measure. Typically, projections will be based on three different levels of attrition, a high, intermediate, and low estimate. In this report, the intermediate level is assumed to be 10%. This level was chosen by judgment after reviewing one national study and conducting several telephone inquiries to state officials.

Numerous factors influence the attrition rate, and the general availability of jobs is surely one. Thus, when jobs are scarce and unemployment is high, it is likely that fewer teachers would leave voluntarily. Little would be gained by elaborating at length on the factors which can influence the attrition rate. Suffice it to say, that improvements in the assumptions about turnover simply must await the collection of data from school systems.

In summary, the analysis of the demand for vocational teachers and projections of future demand require some estimate of enrollments and of the student-teacher ratio. Also, there will be some additional demand due solely to the need to replace teachers who leave.

In the following sections, we will examine patterns of enrollments and projected enrollments with certain data. Also, the size of the teaching staff is examined. In the final section, issues are identified which must be addressed if any improvements are to be made in the projection statistics.

DESCRIBING AND PROJECTING TRENDS IN VOCATIONAL EDUCATION: ENROLLMENTS AND TEACHERS

Trends in vocational enrollments. There are eight basic areas of vocational education: agriculture, distribution, health, consumer and homemaking, home economics occupational preparation, business and office, technical, and trades and industry. Enrollments at the secondary, postsecondary, and adult levels combined are displayed in Table 1, from 1971 through 1978. Total enrollments have increased from 9.034 million in 1971 to 13.957 million in 1978. Such increases carry concomitant increasing requirements for teachers.

The last two lines of Table 1 contain total public secondary and postsecondary enrollments and the percentages of these enrollments which are vocational, covering the same time period. These numbers exclude students enrolled in private, preparatory schools and hence underestimate total vocational enrollments. The percent of school enrollments which are vocational has increased from 34% in 1971 to 46% in 1978. Thus not only have the vocational enrollments been increasing since 1971, the relative share of public school enrollments which are vocational have been increasing as well. Again the greater emphasis on vocational education, implied by these statistics, will generate new and additional demands for teachers.

Table 1 also contains the enrollment projections gleaned from the five-year state plans. The first year for which such projections were made was 1978. Hence, we may compare the enrollments reported to the Office of Education for 1978 with those which had been projected for 1978. The difference between the 1978 Actual column and the 1978 Projected column in Table 1 will provide a summary measure of the accuracy of the state plan projection data.

For total enrollments, projections were underestimated by 1.9 million, or 13%. In agriculture, enrollments were projected to decline, which they did. In health, consumer and homemaking, business and office, technical, and trades and industry, enrollments were projected to decline, while in fact they increased. In distribution and home economics occupational preparation, significant declines were projected, while only small declines actually took place.

TABLE 1

VOCATIONAL EDUCATION ENROLLMENTS BY PROGRAM, 1971-1978
AND PROJECTED ENROLLMENTS 1978-1982
(In Thousands)

Programs	Actual[a]								Projected[b]				
	1971	1972	1973	1974	1975	1976	1977	1978	1978	1979	1980	1981	1982
TOTAL Vocational Education	9,304	10,257	11,011	11,836	12,537	13,216	13,798	13,957	12,089	12,728	12,965	13,522	14,557
Agriculture	838	889	920	968	1,007	1,005	1,051	1,001	1,005	1,031	1,045	1,066	1,084
Distribution	568	629	725	822	867	891	956	954	903	949	991	1,040	1,085
Health	268	335	419	503	615	683	739	757	661	702	722	756	777
Consumer and Homemaking	2,865	3,093	3,121	3,136	3,222	3,448	3,547	3,590	2,598	2,745	2,816	2,938	2,974
Home Economics Occupational Preparation	194	275	317	490	458	469	509	457	426	449	461	480	488
Business and Office	2,207	2,330	2,476	2,732	2,930	3,096	3,254	3,294	2,906	3,053	3,046	3,185	3,204
Technical	312	335	362	391	446	483	517	525	454	477	492	510	520
Trades and Industry	2,052	2,371	2,671	2,794	2,992	3,091	3,225	3,380	3,136	3,322	3,392	3,547	4,425
Public Secondary and all Postsecondary Education[c]	27,342	27,636	28,597	28,895	30,336	29,917	30,038	28,951	30,047	29,791	29,468	29,138	28,860
Percent Vocational[d]	34	37	39	41	41	44	46	48	40	43	44	46	50

a Vocational and Technical Education, Selected Statistical Tables (Fiscal Years 1971-1978); U.S. Office of Education, Bureau of Occupational and Adult Education, Washington, D.C.

b Five-Year State Plans for Vocational Education 1978-1982

c Projection of Education Statistics to 1968-87. National Center for Education Statistics

d Total vocational enrollment as a percent of public secondary and all postsecondary enrollments

Past and projected enrollments are summarized in Figure 2. For purposes of analyzing the demand for teachers, there should be some form of a continuous curve, which would link enrollments with projected enrollments in an orderly and sensible fashion. The areas in Figure 2 are discontinuous, reflecting the 13% underestimate in 1978 projected enrollments. Further, if we search for that year which would reflect an absolute increase in enrollments from 1974, it would be 1982.

Adequate projection of teacher demand requires adequate projections of enrollments. The present analysis leads us to the conclusion that our enrollment projections are not very valid; hence, estimates of additional teachers required will be low, projecting fewer teachers than actually required. We will examine the consequences of these enrollment projections for teacher demand projections later.

To further demonstrate the invalidity of the enrollment projections, and the conflicting nature of the alternatives, three different enrollment estimates are compared. To develop alternative estimates of enrollments we made two different assumptions: first, that the proportion of total enrollments which are vocational would remain constant at 45.9%, the 1977 level, and second, that the proportion of total enrollments which are vocational would increase 1% per year, leveling off at 50% in 1982.

Figure 3 contains curves for each of the two estimates previously described and that from the state plans. Since overall enrollments in secondary schools are declining, the assumption that the percent of vocational enrollments will remain constant leads to a declining vocational enrollment. However, the past trend has been one of an increase in the percentage of students who enroll in vocational education. With a crude extrapolation of this assumption, even in the wake of declining enrollments overall, vocational enrollments would increase. Comparing these two alternatives with the enrollment projections from the state plans leads to divergent conclusions. Hence, the state plan data cannot be corrected in a straight forward manner.

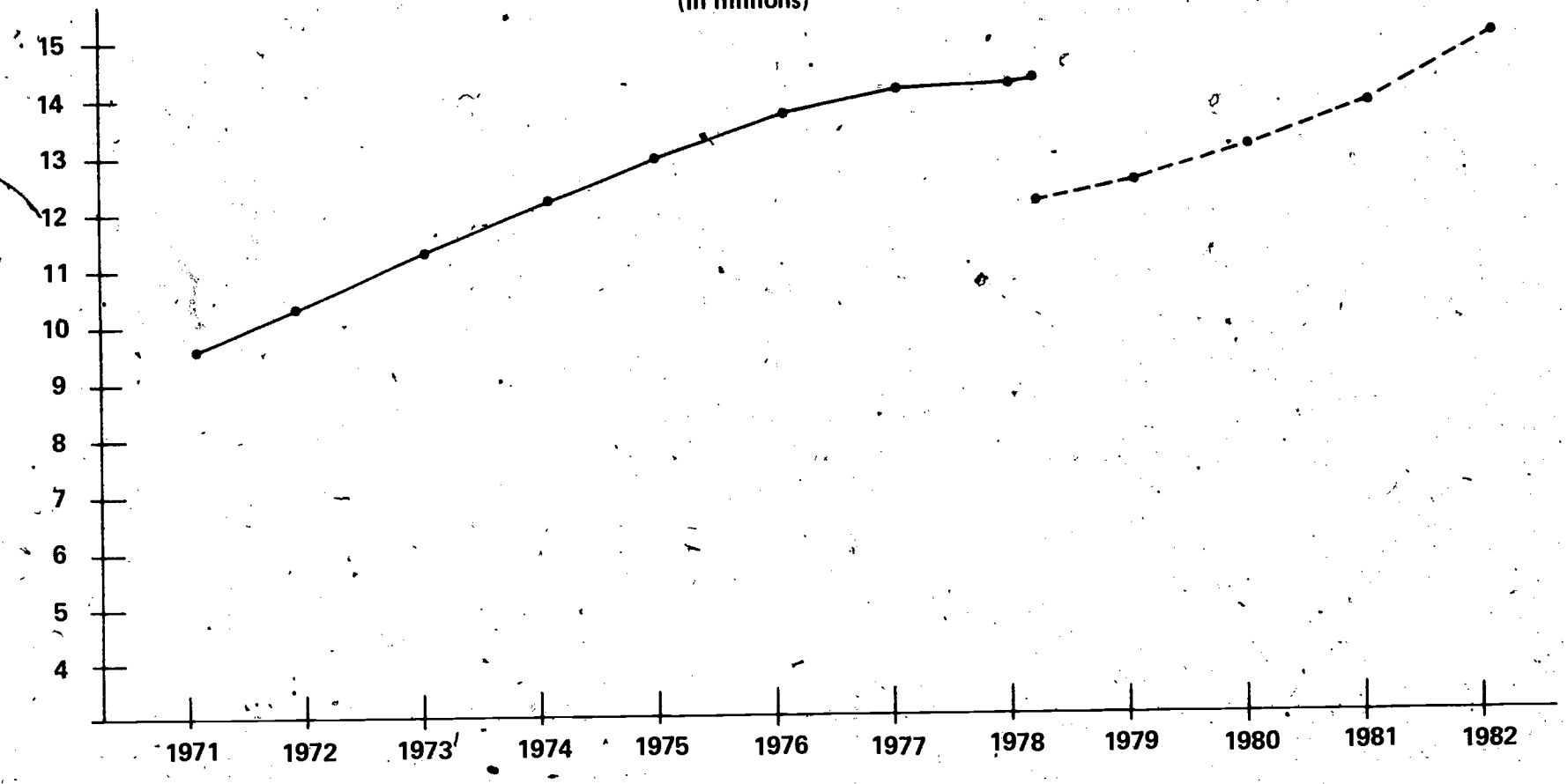
While it might be interesting to actually compute a variety of enrollment and teacher demand projections, the present study presumed the availability of accurate data from the state plans. Tabulations employing the state projections lead to substantial inconsistencies and discrepancies between 1978 actual and projected enrollments. Thus, the further use of these inaccurate state level enrollment projections would generate untrustworthy national projections. The remainder of the present section will point out how these defective enrollment projections in turn produce erroneous projections of teacher demand.

Figure 2

Total Vocational Education Enrollments,

1971-1978[a] and Projected Enrollments 1978-1982[b]

(in millions)



Actual enrollments

Projected enrollments

a *Vocational and Technical Education, Selected Statistical Tables* (Fiscal Years 1971-1978; U.S. Office of Education, Bureau of Occupational and Adult Education, Washington, D.C.

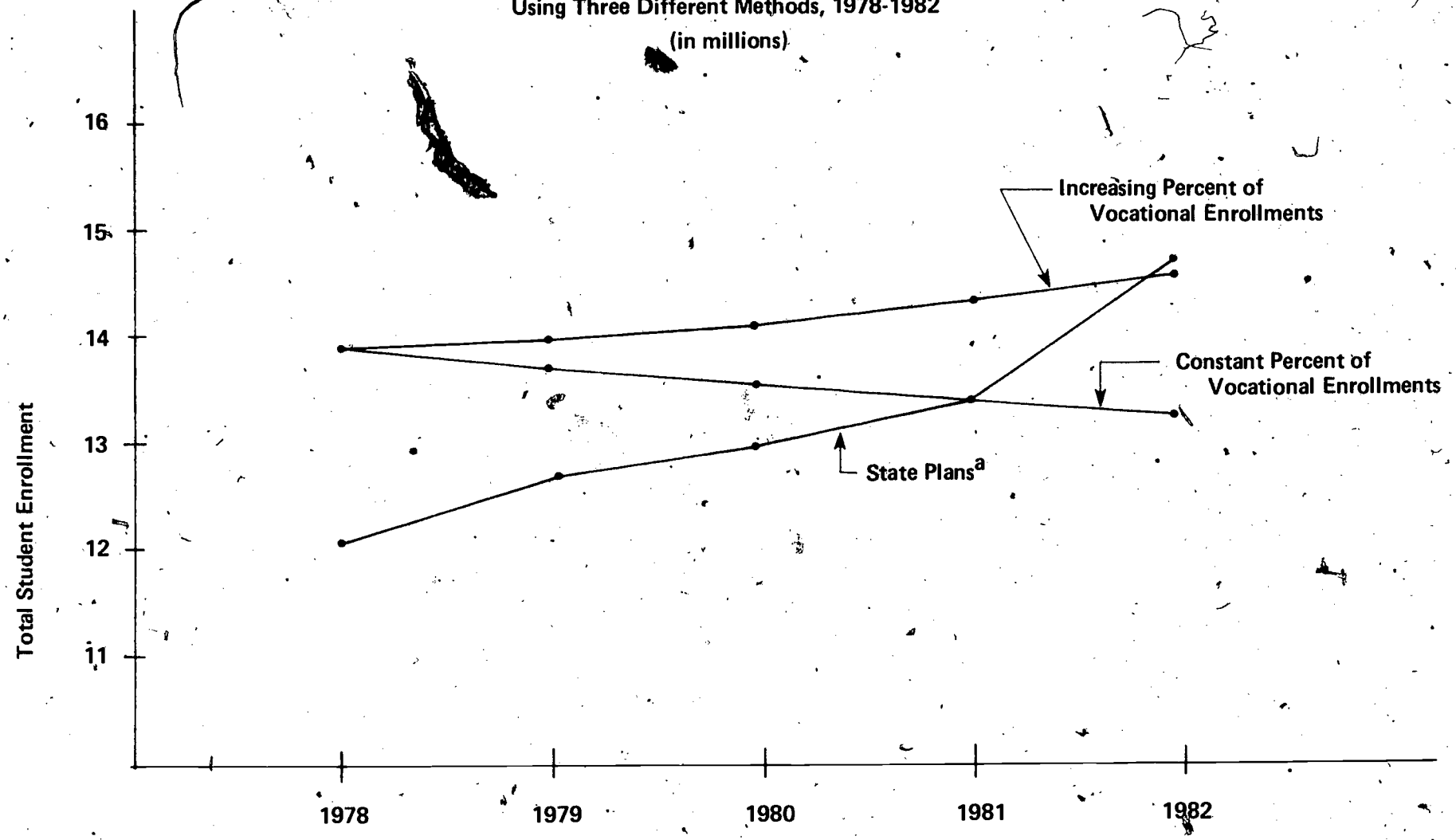
b Five-Year State Plans 1978-1982

Figure 3

Projected Vocational Enrollments

Using Three Different Methods, 1978-1982

(in millions)



[a] Five-Year State Plans 1978-1982

Trends in Teacher Demand

The numbers of vocational teachers in the eight program areas reported by the states since 1971 are presented in Table 2. Since 1971, the number of teachers has increased steadily from 197,000 to 299,000 in 1978, an increase of 52%. The increase in size of the teaching staff has kept pace with increasing enrollments, which increased 50% from its 1971 level.

The rates of increase of teaching staffs have not been equal across the eight program areas. Home economics occupational preparation and health teachers both found their numbers more than doubling. Distribution teachers advanced, and the increase in the number of trades and industry kept pace with the overall increase. Agriculture, consumer and homemaking, business and office, and technical teachers increased at a rate lower than the average.

Using the student-teacher ratio calculated from the 1977 data reported by the states to the Office of Education and using the enrollments projected in the five-year state plans, we calculated the number of teachers needed for years 1978 through 1982. These results show that far fewer teachers would be demanded than even the present number of 299,000.

The interpretation is quite straightforward: a serious underestimate of enrollments will produce a similarly serious underestimate of teacher demand. Among the eight program areas, trades and industry projected a demand for teachers somewhat more than was observed, while for the rest, the projections were less than was observed.

The statistics in Table 2 indicate that too many teachers presently exist and that the total number of teachers should not increase until 1981. The conclusions are clearly wrong, and due primarily to deficiencies in enrollment projections.

We did not calculate the total additional demand for teachers. These figures could be obtained by subtracting the number of teachers for any two consecutive years and adding some percentage of the earlier year to account for those teachers who must be replaced. To do so, would yield numbers with an even less clear meaning than those in Table 2. The number of teachers not needed due to the drop in enrollment projections would be partially offset by an increase due to attrition. The analysis of these statistics purporting to measure total additional demand would not be useful at this point.

TABLE 2

VOCATIONAL EDUCATION TEACHERS BY PROGRAM, 1971-1978
AND PROJECTED TEACHER DEMAND, 1978-1982
(In Thousands)

Programs	Actual[a]								Projected				
	1971	1972	1973	1974	1975	1976	1977	1978	1978	1979	1980	1981	1982
TOTAL	197	215	227	243	266	278	298	299	275	290	295	308	335
Agriculture	13	13	14	15	15	17	17	18	17	17	17	18	18
Distribution	12	14	15	16	18	20	21	22	20	21	22	23	24
Health	13	14	17	19	21	24	27	28	25	26	27	28	29
Consumer and Homemaking	32	35	37	40	40	38	41	41	32	33	34	35	36
Home Economics Occupational Preparation	5	6	6	7	10	12	12	12	11	11	12	12	13
Business and Office	49	52	54	58	66	67	70	70	65	68	68	71	71
Technical	15	17	14	15	16	17	19	21	17	18	18	19	19
Trades and Industry	58	64	70	73	80	83	91	87	90	96	97	102	125

a Vocational and Technical Education, Selected Statistical Tables (Fiscal Years 1971-1978); U.S. Office of Education, Bureau of Occupational and Adult Education, Washington, D.C.

CONCLUSIONS AND RECOMMENDATIONS

There will continue to exist an interest in the demand for and supply of teachers. The results of the present research will surely not turn attention away from the problem. What can be done to improve the data or the methods used in the present report?

First and foremost, more valid projections of enrollments need to be developed. We had no a priori reason for rejecting projections from the state plans. However, analyses comparing actual and projected 1978 enrollments show that we are unable to make predictions of future demand for teachers using these data. More improvements can be made in the quality of enrollment projections by disaggregating the secondary, postsecondary, and adult enrollment data and simply making statistical projections based on recent trends. To do this, however, substantial effort would have to be devoted to analyzing the disaggregated data from the state reports to the Office of Education.

Secondly, stable estimates of the student-teacher ratio should be developed. Our earlier analysis documented the extreme sensitivity of teacher demand to the ratio. The student-teacher ratio should be disaggregated by the secondary, postsecondary, and adult levels and projected statistically from recent trends. The reason is that the absolute size of the ratio varies substantially by level and by program area.

Finally, additional benchmark data describing teacher turnover need to be developed. The figure of 10% was used in this project, but for practical reasons. A small study of vocational agriculture teachers found a national attrition rate of 10%. No other program areas have been studied at the national level.

It is useful to supplement analyses of teacher demand with those of teacher supply. For example, how well do vocational teachers fare in the job market? While not a complete answer, the finding that the average vocational teacher is most likely to find employment indicates a high demand situation.

In addition to the basic improvements in the quality of data used to make projections to teacher demand, more data describing the supply of vocational teachers and their labor market behavior would certainly broaden the use and meaning of demand statistics.