Strategies for estimating teacher supply and demand using student and teacher data

Applied Research Methods

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The Minnesota Department of Education partnered with Regional Educational Laboratory Midwest to redesign the state's teacher supply and demand study in order to increase its utility for stakeholders. This report summarizes the four-step process that was followed in redesigning the study, focusing on the state data sources and analytic methods that can address stakeholders' research questions. Because many data elements used in the study are common across states, the process described may help stakeholders in other states improve their studies of teacher supply and demand.

Why this study?

Every year the U.S. Department of Education reports for each state in the country the grade levels, subject areas, and geographic areas that have experienced teacher shortages (U.S. Department of Education, Office of Postsecondary Education, 2015). A teacher shortage occurs when the number of teachers available in a specific grade, subject matter or discipline classification, or geographic area—teacher supply—is less than the number of teachers required in that grade, subject matter or discipline classification, or geographic area—teacher demand. States are required to report shortages to the U.S. Department of Education each year to qualify for federal programs that allow states to offer teachers incentives, such as loan deferment, loan cancelation, and scholarships, to teach in shortage areas.

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Some states, including Minnesota, require their state education agency to go beyond reporting teacher shortage areas to producing a detailed analysis of teacher staffing patterns (Lindsay, Wan, & Gossin-Wilson, 2009). By law the Minnesota Department of Education must conduct a multimethod teacher supply and demand study every two years (Minnesota Statute § 127A.05, subd. 6, 2015). The law requires the department to administer a biennial survey of school districts and a survey of teacher preparation institutions, report findings on patterns of shortages by subject area and region, and produce five-year projections of teacher demand by district. Between 2005 and 2011 the Minnesota Department of Education repeated the same teacher supply and demand study, administering similar surveys and performing similar analyses. Many education stakeholders in Minnesota called for a redesign of the study to change it from an unfocused compilation of summaries of data analyses to a report that answered explicit research questions. Minnesota members of the Midwest Educator Effectiveness Research Alliance partnered with a technical assistance team from Regional Educational Laboratory Midwest to redesign Minnesota's teacher supply and demand study to enhance its utility for stakeholders.

A four-step process was followed in redesigning the study:

- Identifying and refining research questions.
- Identifying data sources and analytic methods to address each research question.
- Collecting and preparing data for analysis.
- Analyzing data and reporting findings.

This report describes the steps in more detail, emphasizing the methods for addressing each research question. Because many data elements used for the study are common across states, this report may help researchers in other states or school districts study teacher staffing patterns in their jurisdictions.

Step 1. Identifying and refining research questions

The Minnesota Department of Education solicited opinions from stakeholder groups, including legislators, leaders of educator professional organizations, representatives of teacher preparation institutions, and the state teachers union on the utility of previous teacher supply and demand reports and the questions stakeholders wanted addressed. The technical assistance team helped the department shape the questions into ones that could be answered empirically. The final research questions were:

1. What have been the five-year trends in teacher supply and demand? Do the teacher supply trends vary by teacher race/ethnicity?

2. Which teacher certification areas are experiencing shortage or surplus? Do the teacher shortage areas vary by region of the state, school type (charter or noncharter), or school locale (rural or urban)?

3. What barriers do district staff members perceive as impairing their ability to hire effective teachers?

4. What factors do teacher preparation institutions cite as influencing their ability to prepare effective teachers now and for the next 10 years?

5. What K–12 public school enrollment trends are expected for particular student subgroups (for example, racial/ethnic categories or English learner students) over the next 3, 5, and 10 years?

Step 2. Identifying data sources and analytic methods to address each research question

Step 2 involved three substeps: reviewing the literature to identify data sources and analytic methods used by other research teams, examining existing data to determine which data could be used to address the research questions, and working with Minnesota Department of Education staff to finalize the methods for addressing each research question.

Reviewing the literature to identify data sources and analytic methods used by other research teams

The technical assistance team reviewed studies that measured teacher supply and demand and were published between 1983 and 2012, focusing on studies that addressed research questions similar to those posed by the Minnesota Department of Education. The studies were then categorized according to which research question they examined. For each research question the technical assistance team summarized the data sources and methods employed in the literature and considered the advantages and disadvantages of each method.

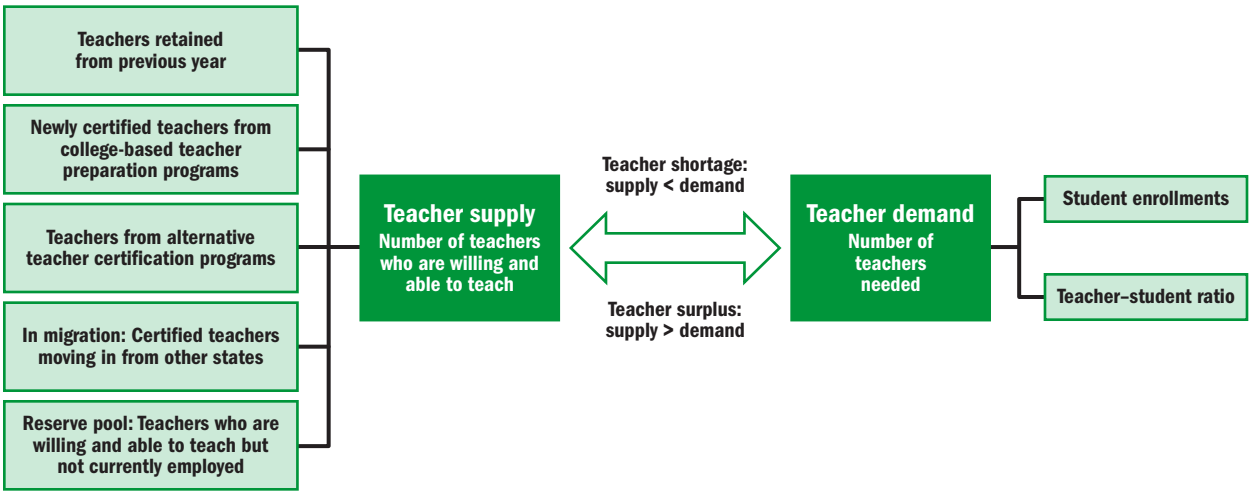
Conceptually, one way to determine whether a teacher shortage or surplus exists in an area is to compare the number of teachers from all sources who are willing and able to teach with the number of teachers needed as determined by student enrollment (figure 1).

The literature review found two common approaches for identifying teacher shortages:

- Single-indicator approach: using data from a single source to determine teacher shortage areas.
- Component summation approach: aggregating separate estimates for the teacher supply components and the teacher demand components and comparing the two estimates.

Single-indicator approach. The single-indicator approach identifies teacher shortages on the basis of data from a single indicator. For example, some states identify areas of shortage by examining the number of job postings for teachers in specific content areas and the length of time required to fill the vacant positions (Lindsay et al., 2009). Another indicator is the number of special permissions requested by districts (Hare, Nathan, Darland, & Laine, 2000; Lashway, Maloney, Hathaway, & Bryant, 2005).[1] When the demand for teachers is greater than the supply—such as when schools cannot find enough certified teachers to fill

Figure 1. The components of teacher supply and demand



Source: Adapted from Lindsay et al. (2009).

vacancies—school districts are required to apply for special permission to allow individuals without the proper certificate to temporarily fill the vacant positions.

Component summation approach. Some researchers have attempted to estimate the magnitude of teacher shortages, as a whole or for specific certificate areas, by aggregating the estimates for multiple components of teacher supply and demand (the five components of teacher supply on the far left of figure 1 and two components of teacher demand on the far right of the figure; for example, Aaronson & Meckel, 2009; Berg-Jacobson & Levin, 2015). The advantage of this approach is that it allows researchers and policymakers to see not only the severity of the shortage, but also whether the magnitude of the shortage is related to changes in one or more components. The disadvantage of this approach is that combining multiple estimates into a single estimate can compound the errors in the component estimates.

By reviewing the research on teacher supply and demand, the technical assistance team was able to catalog indicators reflective of teacher shortage areas that researchers have used in previous studies as well as the types of data that can be used to assess each of the components of teacher supply and demand.

Examining existing data sources to determine which data could be used to address the research questions

The technical assistance team performed a gap analysis to determine whether the types of data used in previous studies were available within the datasets already developed and maintained by the Minnesota Department of Education, the Minnesota Board of Teaching, or other national or state public agencies or professional organizations. The technical assistance team determined that teacher supply sources could be assessed using the teacher certificate database and school staffing data. The certification data show the number of new teaching certificates awarded each year to completers of in-state teacher preparation programs (a proxy for the number of completers from teacher preparation institutions each year). The staffing data collected from school districts and charter schools twice a year show whether teachers were teaching in the same school as in the previous year (that is, retained in their position), were returning after a break in service, were newly certified from a Minnesota teacher preparation institution, were newly certified but prepared out-of-state, transferred from another Minnesota public school district, or transferred from outside the Minnesota public school system.

On the demand side the Minnesota Department of Education maintains records of school enrollments by grade level, student race/ethnicity, and special student population (for example students eligible for the federal school lunch program, English learner students, and students receiving special education services). Average teacher–student ratios are available from districts' financial reports, which are submitted to the Minnesota Department of Education each year. The Minnesota Board of Teaching also maintains records of school districts' requests for special permissions to allow teachers to teach courses for which they are not certified.

However, no data sources were found that measured either district leaders' perceptions of barriers to hiring and retaining effective teachers or the factors that leaders of teacher preparation institutions believe influence their ability to prepare teachers in shortage areas. Measuring the perceptions of leaders in districts and teacher preparation institutions would require gathering additional data.

Working with Minnesota Department of Education staff to finalize the methods for addressing each research question

For each research question the technical assistance team and representatives of the Minnesota Department of Education jointly determined which methods to use on the basis of data availability, validity and reliability, and cost. Most of the methods chosen involved use of administrative data maintained by the department (table 1).

Table 1. Data sources, variables, and analytic methods used to address Minnesota's questions about teacher supply and demand

Data source and variable	Analytic method
Research question 1: What have been the five-year trends in teacher supply and demand? Do the teacher supply trends vary by teacher race/ethnicity?	
• Student enrollment data for each of the last five years: enrollment at the district level (by grade and for subgroups). • Staff employment data for each of the last five years: staff employment status. • Staff assignment data for each of the last five years: staff assignment codes. • Teacher certificate data for each of the last five years: staff certification records. • State-level chapter of Association of Colleges of Teacher Education data for the last five years: program completers by certification area. • School financial data for each of the last five years: teacher–student ratios by district.	• Use the following two components to estimate teacher demand: ◦ Student enrollment counts. ◦ Teacher–student ratios. • Use the following four components to estimate teacher supply: ◦ Teacher retention: proportion of teachers in the state who maintain their position from year to year. ◦ Newly certified teachers: • Counts of program completers by certification areas. • Counts of new certificates issued by certification area. ◦ In-migration: the number of certificate applicants who held teacher certificates in other states. ◦ Reserve pool: • Number of teachers returning to teaching positions after time away. • Number of unexpired teaching certificates for individuals younger than age 60. Separate analyses can be conducted by teacher racial/ethnic group, certification areas, and state economic development region.[a]
Research question 2: Which teacher certification areas are experiencing shortage or surplus? Do the teacher shortage areas vary by region of the state, school type (charter or noncharter), or school locale (rural or urban)?	
• Minnesota Board of Teaching's special permission[b] files: permission codes. • Survey of district administrators: questions on how easy or difficult it is to fill vacancies for each area of teacher certification. • Survey of teacher preparation institutions: questions on teacher certification areas for which program completers are experiencing difficulties in finding teaching positions. • School-level data on school type and region (charter or noncharter). • National Center for Education Statistics Elementary and Secondary Information System data: school classification of locale (urban, suburban, town, rural).	• Identify shortage areas ◦ Calculate counts of special permissions by certification area, school type, and school locale. ◦ Identify certification areas most frequently rated by district survey respondents as "very difficult" or "could not fill all vacancies." • Identify surplus areas ◦ Identify certification areas for which districts indicate that vacancies are easy to fill. ◦ Identify certification areas for which teacher preparation institutions indicate that their graduates have difficulties in finding teaching positions. Separate analyses can be conducted by state economic development region, school or district type, or school or district locale.[b]
Research question 3: What barriers do district staff members perceive as impairing their ability to hire effective teachers?	
Survey of district administrators: questions on whether specific state and federal requirements are barriers to hiring and retaining effective teachers. An open-ended question asks about other barriers.	• Calculate the frequencies of districts that selected each response category for the questions on whether state and federal requirements are barriers. • Group responses to the open-ended question on other barriers by theme and tally the number of responses that are aligned to each theme.
Research question 4: What factors do teacher preparation institutions cite as influencing their ability to prepare effective teachers now and for the next 10 years?	
Survey of teacher preparation institutions: two open-ended questions on factors influencing preparation of teachers and suggestions for improvement.	• Group responses to these two items by theme and tally the number of responses that are aligned to each theme.
Research question 5: What K–12 public school enrollment trends are expected for particular student subgroups (for example, racial/ethnic categories or English learner students) over the next 3, 5, and 10 years?	
• Student enrollment data for each of the last ten years. • Census data and population estimates between census years for each of the last five years: population estimates in five-year ranges. • Birth and fertility statistics for each of the last six years from state health department's website.	• Calculate county-level student enrollment by grade level. • Estimate the number of future births using U.S. Census county-level estimates of the numbers of women who are of childbearing age. • Calculate grade-progression ratios using historical enrollment data. • Use county birth records and projected births for birth-to-kindergarten progression ratios. • Multiply grade-level enrollments by appropriate birth-to-kindergarten progression ratios and grade-progression ratios (appendix A).

a. The Minnesota Department of Economic Development has grouped Minnesota's 87 counties into 13 economic development regions. These regions correspond fairly closely with the special education service cooperative regional support structure that Minnesota has used in the past. Previous Minnesota teacher supply and demand reports have reported findings by this level of analysis as well.

b. The Minnesota Board of Teaching may grant special permission to allow individuals to teach in subject or content areas for which they are not fully certified when a school district has attempted to hire a fully certified teacher and been unable to do so.

Source: Technical assistance team review of research literature and gap analysis conducted for this project.

To examine five-year trends in teacher supply (part of research question 1), the team used teacher certification data to calculate the numbers of new teacher certificates issued for each of the last five years (by type and content area of the certificate) and used staffing data to calculate the number of teachers who were retained from the previous year, migrated in from another state, received alternative certification, or were returning to teaching after a break in service (by certificate type and content area). The team also examined the trends in teacher supply by teachers' race/ethnicity (available on teacher certificates and staffing data). To assess five-year trends in teacher demand (another part of research question 1), the study team examined student enrollments in schools by grade level, race/ethnicity, and special population as well as districts' teacher–student ratios for each of the last five years. Teacher demand was estimated with an enrollment-based equation used in other studies (for example Aaronson & Meckel, 2009; Zhang, 2011):

$$\textit{Teacher demand} = \frac{\textit{Enrollment}}{\textit{Teacher–student ratio}}$$

The single-indicator approach was used to identify areas of teacher shortage and surplus (research question 2). By counting the numbers of positions requiring special permissions by teacher content area, the technical assistance team was able to show the subject areas in which teacher demand exceeded teacher supply. The number of special permissions was also cross-tabulated with region of the state, school type (charter or noncharter), and locale (rural or urban). Responses to the district survey were used to confirm shortage areas (those where the greatest number of respondents indicated that it was very difficult to fill vacancies or that they were unable to fill all vacancies) and surplus areas (those where respondents said vacancies were easy to fill).[2] Respondents to the survey of teacher preparation institutions also provided information on potential surplus areas by identifying the certification areas where teaching program graduates had difficulty finding teaching positions.

To address research question 3, the technical assistance team wrote seven survey questions that were added to the district survey. Three questions asked whether certification standards, teacher testing requirements, and federal requirements that public school teachers be highly qualified posed a small barrier, a large barrier, or no barrier to hiring effective teachers. Three questions asked whether those same three policies posed barriers to retaining effective teachers. The seventh question was open-ended: "What other factors are barriers for your district in hiring and retaining effective teachers?"

To address research question 4, the technical assistance team also wrote two open-ended questions for the survey of teacher preparation institutions:

> Are there institutional or public-policy-related factors you believe present challenges for your institution's capacity to prepare teachers in areas of teacher shortage over the next 10 years? If yes, please describe those factors.
>
> Please use the space below to offer suggestions for policies or programs that might improve the recruitment, admission, and preparation of teacher candidates in shortage areas.

To address research question 5, the technical assistance team used historical school enrollment data going back as far as 1992/93 to test a variety of methods for making 3-year, 5-year, and 10-year enrollment forecasts. These methods included using present enrollment numbers, enrollment numbers with a constant average growth rate, grade-progression ratios, and a variety of regression models. The amount of error in forecast models was estimated using the average percent error and the mean absolute percent error. The error estimates from each model were presented to the Minnesota Department of Education, and the department and the technical assistance team jointly decided to use the model that produced the smallest amount of error: the model that used grade-progression ratios.[3] A more detailed description of this method is presented under step 4.

Step 3. Collecting and preparing data for analysis

The Minnesota teacher supply and demand study used administrative data collected and maintained by the Minnesota Department of Education or other state or national public agencies or professional organizations (see table 1), as well as data collected through two mandated surveys—the survey of school districts and the survey of teacher preparation institutions. The technical assistance team reviewed the prior versions of the two surveys and helped the department revise them so that the surveys would produce valid and reliable data while minimizing the burden on respondents. The team added new questions to each survey to address research questions 3 and 4 (see step 2).[4] The technical assistance team also created documents to support the department in administering the surveys and improving response rate, including a timeline for administering the survey and sample text for e-mail communications to the pool of potential respondents.

The Minnesota Department of Education sent the district surveys to the administrator in each district or charter school who oversaw school staffing. The survey of teacher preparation institutions was sent to representatives of 32 institutions in Minnesota.

To provide the Minnesota Department of Education with guidance on preparing extant data and survey data for analysis, the technical assistance team drew the necessary data from online sources and requested staffing data and survey data from the department. The technical assistance team provided explicit step-by-step directions on how to clean, edit, merge, aggregate, and organize the data prior to analysis and wrote statistical programming code to perform those tasks.[5] Examples also were provided to illustrate some complicated calculations. Staff analysts at the Minnesota Department of Education who are familiar with the administrative data files and who have basic data skills would be able to follow these instructions and use the programming code to perform data cleaning and preparation tasks for teacher supply and demand studies.

Step 4. Analyzing data and reporting findings

Step 4 involved four substeps:

- Assessing the five-year trends in number of teachers from the various supply sources, number of students per grade level, and teacher–student ratio (research question 1).
- Identifying statewide shortage areas and comparing shortage areas by school type and locale using the single-indicator approach (research question 2).
- Identifying challenges and barriers to preparing, hiring, and retaining effective teachers using survey data (research questions 3 and 4).
- Forecasting public school enrollments using grade-progression ratios (research question 5).

Assessing teacher supply and demand trends using data on teacher supply sources and demand components

To address research question 1, the technical assistance team counted the number of teachers from the various supply sources (teachers retaining their positions, newly certified teachers from in-state teacher preparation programs, newly certified teachers from alternative teacher certification programs, teachers from other states, and teachers returning to teaching after a break in service) for each of the five previous years. The findings can be presented in a pie chart or stacked bar charts (one bar for each year). The total supply numbers also were cross tabulated by teacher race/ethnicity. The technical assistance team also documented school enrollments and teacher–student ratios over the past five years.

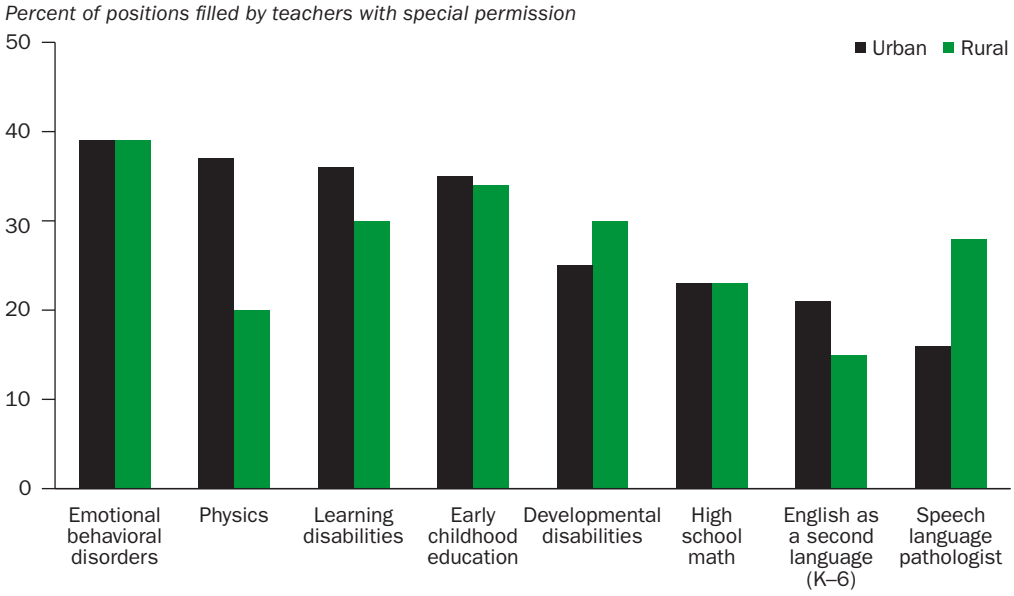
Comparing shortage areas by region of the state, school type, and school locale using the single-indicator approach

To address research question 2, the technical assistance team counted the number of applications for special permissions by certification area, region, school type, and school locale. For example, the certification areas with the most applications for special permissions in public school districts were examined side by side with the certification areas with the most applications for special permissions in charter schools. The analyses of areas of shortage by region of the state and locale (rural or urban) were similar. Figure 2 illustrates how areas of shortage for different locales can be displayed. Counts of licensure areas most frequently rated as "very difficult" or "could not fill all vacancies" by district hiring officers who responded to the district survey also provided confirmation from the field about areas in which too few qualified applicants exist to meet districts' staffing demands. Counts of licensure areas most frequently rated as "easy" to fill by district hiring officers and counts of licensure areas most frequently noted by teacher preparation institutions as most difficult to place teaching program graduates suggested potential areas of teacher surplus.

Identifying challenges and barriers to preparing, hiring, and retaining effective teachers using survey data

To address research questions 3 and 4, the technical assistance team used the responses of school district leaders to the district survey and the responses of leaders of teacher preparation institutions to items on the institution survey. The challenges and barriers to hiring and retaining effective teachers were determined in two ways. First, for the closed-ended survey items asking about specific policies, the frequencies of districts that selected each response category (whether the policy posed no barrier, a small barrier, or a large barrier) were tabulated. Second, to analyze the responses to the open-ended question, respondents' comments were grouped by theme, and the number of respondents who made statements aligned to each theme was tallied and analyzed. The responses of leaders of teacher preparation institutions to the open-ended items about factors that challenge their institution's ability to prepare teachers in areas of teacher shortage

Figure 2. Sample bar chart displaying special permissions by subject area and locale type



Note: The figure does not reflect real data. Special permissions are requested by districts when they are unable to fill teaching positions with a properly certified teacher. For Minnesota the number of special permissions represents the degree to which teacher demand exceeds teacher supply for that certification area.

Source: Authors' construction.

also were grouped by theme, and the number of institutions making statements aligned with each theme was tallied and analyzed.

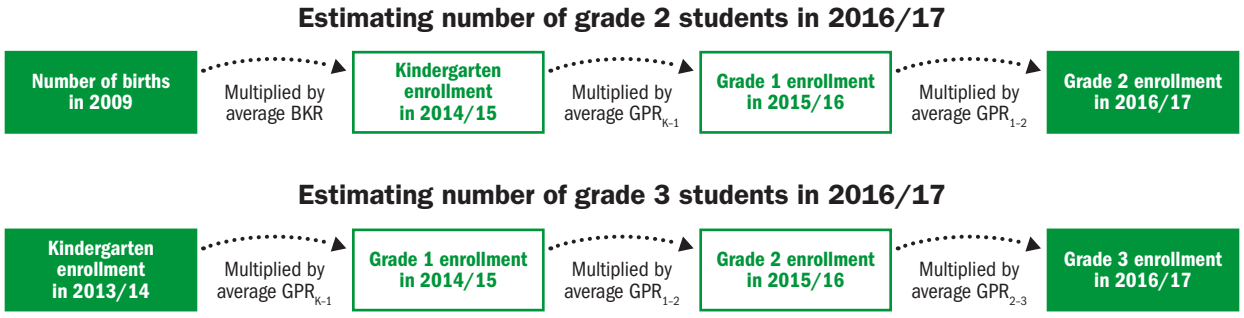
Forecasting public school enrollments using grade-progression ratios

To address research question 5, the technical assistance team tested several forecasting models using historical enrollment data. The model that produced the smallest estimation errors was ultimately adopted. The model incorporated enrollment numbers by grade level during the year of the study, the number of children born in each of the past six years,[6] and the average proportion of students in each grade-level cohort who were promoted to the next grade level during the following year (referred to as grade-progression ratio) averaged over multiple years.[7] In this approach, forecasting future annual enrollment becomes a process of multiplication—the number of children in each cohort is multiplied by the grade-progression ratio for the grade levels that fall between their present grade and the grade level they would be in if they were promoted each year (see figure 3 and appendix A for the calculations of 3-, 5- and 10-year forecasts).

To estimate the number of students in kindergarten in a future year, the birth-to-kindergarten ratio was calculated (the average proportion of children born in a given year who will enter kindergarten five years later).[8] For forecasts that go beyond four years (for which no actual birth data are available), the number of births were estimated using the number of women who will be in their child-bearing years (ages 15–44) during the birth year in question multiplied by the fertility rate (defined as the number of births per 1,000 women in the 15–44 age group). Once forecasts were made for each grade level, the total enrollment forecast could be calculated using the sum of these grade-level forecasts.

Embedded within research question 5 are two subquestions. First, what will overall student enrollments look like in 3, 5, and 10 years? And second, how will enrollments among subgroups change? The technical assistance team suggested that the Minnesota Department of Education refrain from looking at trends among specific racial/ethnic subgroups because some of the groups were relatively small and grade-progression ratios are more prone to error when examining small groups. Instead, forecasts for White students and students representing racial/ethnic minority groups generally were compared because those forecasts were deemed more accurate. The findings show historical and future trends for enrollments generally as well as trends in the relative percentages of students in White and racial/ethnic minority subgroups (figure 4).

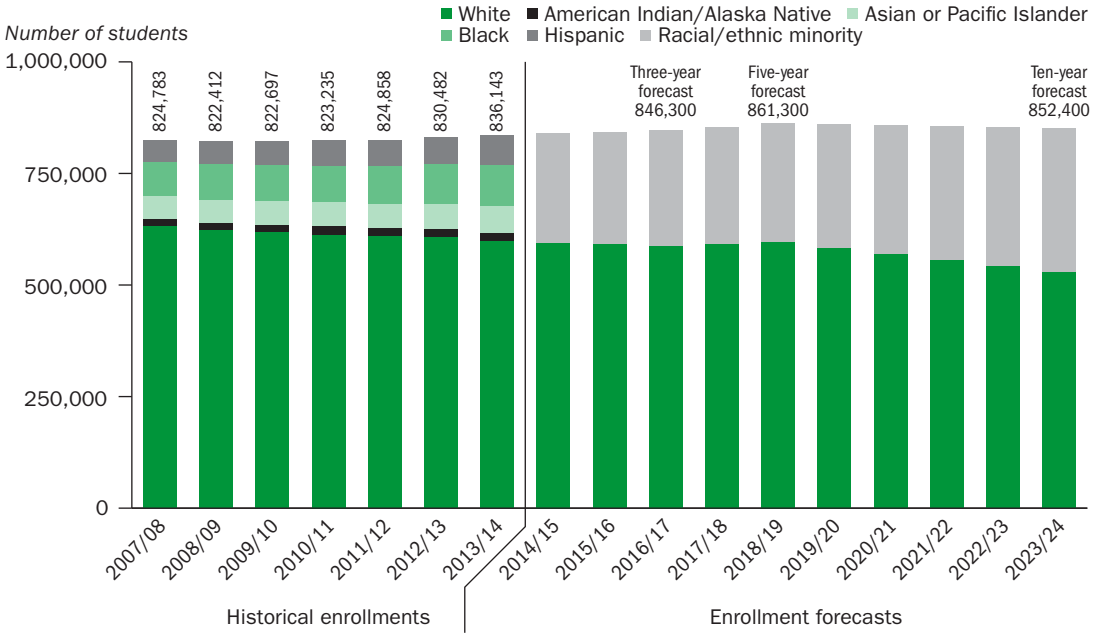
Figure 3. Sample process for forecasting enrollment of grade 2 and grade 3 students in three years using data available in 2013/14 and the average birth-to-kindergarten ratios and grade-progression ratios



Note: BKR is birth-to-kindergarten ratio; GPR_{X-Y} is grade-progression ratio from grade *X* to grade *Y*, where grade *Y* = grade *X* + 1.

Source: Authors' literature review of methodologies for making enrollment forecasts.

Figure 4. Sample graph displaying statewide forecasts made in 2013/14 of overall enrollments and percentages of racial/ethnic minority students for K–12 public schools



Note: The figure does not reflect real data. Numbers above stacked columns are historical and forecast total student enrollments for grades K–12. Racial/ethnic minority groups are combined in forecasts for better accuracy.

Source: Authors' construction.

Conclusion

States are required to report teacher shortage areas annually to the U.S. Department of Education; however, some states conduct more in-depth analysis of the factors that might be driving teacher shortages (Lindsay et al., 2009). Determining the scope of such analyses depends on a state's need to alleviate shortage areas, the state's capacity to conduct such a study, and the state's willingness to invest time and money in the process. For example, Minnesota spent almost $20,000 in 2015 to conduct its teacher supply and demand study, and by doing so, has revealed several issues that require resolution to improve the balance between teacher supply and demand (Minnesota Department of Education, 2015).

The methodologies that states use to examine teacher supply and demand depend on the research questions being asked. States in which stakeholders ask questions similar to those that underlie Minnesota's study may want to use the methodologies described in this report. As noted, these methodologies were based on available data sources, the quality of those data, the resources that the Minnesota Department of Education had to collect new data, statutory requirements, and the questions being addressed. The circumstances in other states may differ. By following the process outlined in this report, states can identify the data and analytic methods needed to conduct their own study of teacher supply and demand.

Appendix A. Calculations for 3-year, 5-year, and 10-year forecasts of student enrollment by grade

This appendix shows the calculations needed for 3-year, 5-year, and 10-year forecasts based on grade-progression ratios (tables A1, A2, and A3) and birth-to-kindergarten ratios.

Table A1. Sample calculations for 3-year forecasts from 2013/14 school year

Grade in three years (2016/17)	Status of cohort in 2013/14	Calculations for 3 year forecasts to 2016/17 school year
12	In grade 9	Number of students in grade 9 in 2013/14 * $GPR_{9–10}$ * $GPR_{10–11}$ * $GPR_{11–12}$
11	Grade 8	Number of students in grade 8 in 2013/14 * $GPR_{8–9}$ * $GPR_{9–10}$ * $GPR_{10–11}$
10	Grade 7	Number of students in grade 7 in 2013/14 * $GPR_{7–8}$ * $GPR_{8–9}$ * $GPR_{9–10}$
9	Grade 6	Number of students in grade 6 in 2013/14 * $GPR_{6–7}$ * $GPR_{7–8}$ * $GPR_{8–9}$
8	Grade 5	Number of students in grade 5 in 2013/14 * $GPR_{5–6}$ * $GPR_{6–7}$ * $GPR_{7–8}$
7	Grade 4	Number of students in grade 4 in 2013/14 * $GPR_{4–5}$ * $GPR_{5–6}$ * $GPR_{6–7}$
6	Grade 3	Number of students in grade 3 in 2013/14 * $GPR_{3–4}$ * $GPR_{4–5}$ * $GPR_{5–6}$
5	Grade 2	Number of students in grade 2 in 2013/14 * $GPR_{2–3}$ * $GPR_{3–4}$ * $GPR_{4–5}$
4	Grade 1	Number of students in grade 1 in 2013/14 * $GPR_{1–2}$ * $GPR_{2–3}$ * $GPR_{3–4}$
3	Kindergarten	Number of students in kindergarten in 2013/14 * $GPR_{K–1}$ * $GPR_{1–2}$ * $GPR_{2–3}$
2	Born four years prior	Number of children born in 2009 * BKR * $GPR_{K–1}$ * $GPR_{1–2}$
1	Born three years prior	Number of children born in 2010 * BKR * $GPR_{K–1}$
K	Born two years prior	Number of children born in 2011 * BKR

Note: BKR is birth-to-kindergarten ratio; $GPR_{X–Y}$ is grade-progression ratio from grade *X* to grade *Y*, where grade *Y* = grade *X* + 1.

Source: Authors' literature review of methodologies for making enrollment forecasts.

Table A2. Sample calculations for 5-year forecasts from 2013/14 school year

Grade in five years (2018/19)	Status of cohort in 2013/14	Calculations for 5 year forecasts to 2018/19 school year
12	Grade 7	Number of students in grade 7 in 2013/14 * $GPR_{7–8}$ * $GPR_{8–9}$ * $GPR_{9–10}$ * $GPR_{10–11}$ * $GPR_{11–12}$
11	Grade 6	Number of students in grade 6 in 2013/14 * $GPR_{6–7}$ * $GPR_{7–8}$ * $GPR_{8–9}$ * $GPR_{9–10}$ * $GPR_{10–11}$
10	Grade 5	Number of students in grade 5 in 2013/14 * $GPR_{5–6}$ * $GPR_{6–7}$ * $GPR_{7–8}$ * $GPR_{8–9}$ * $GPR_{9–10}$
9	Grade 4	Number of students in grade 4 in 2013/14 * $GPR_{4–5}$ * $GPR_{5–6}$ *$GPR_{6–7}$ * $GPR_{7–8}$ * $GPR_{8–9}$
8	Grade 3	Number of students in grade 3 in 2013/14 * $GPR_{3–4}$ * $GPR_{4–5}$ * $GPR_{5–6}$ *$GPR_{6–7}$ * $GPR_{7–8}$
7	Grade 2	Number of students in grade 2 in 2013/14 * $GPR_{2–3}$ * $GPR_{3–4}$ * $GPR_{4–5}$ * $GPR_{5–6}$ * $GPR_{6–7}$
6	Grade 1	Number of students in grade 1 in 2013/14 * $GPR_{1–2}$ * $GPR_{2–3}$ * $GPR_{3–4}$ * $GPR_{4–5}$ * $GPR_{5–6}$
5	Kindergarten	Number of students in kindergarten in 2013/14 * $GPR_{K–1}$ * $GPR_{1–2}$ * $GPR_{2–3}$ * $GPR_{3–4}$ * $GPR_{4–5}$
4	Born four years prior (2009)	Number of children born in 2009 * BKR * $GPR_{K–1}$ * $GPR_{1–2}$ * $GPR_{2–3}$ * $GPR_{3–4}$
3	Born three years prior (2010)	Number of children born in 2010 * BKR * $GPR_{K–1}$ * $GPR_{1–2}$ * $GPR_{2–3}$
2	Born two years prior (2011)	Number of children born in 2011 * BKR * $GPR_{K–1}$ * $GPR_{1–2}$
1	Born one year prior (2012)[a]	Number of women ages 15–44 in 2011 * $\frac{\text{Fertility rate in 2011}}{1{,}000}$ *BKR * $GPR_{K–1}$
K	Born in the study year (2013)[b]	Number of women ages 10–39 in 2007 * $\frac{\text{Fertility rate in 2011}}{1{,}000}$ * BKR

Note: BKR is birth-to-kindergarten ratio; $GPR_{X–Y}$ is grade-progression ratio from grade *X* to grade *Y*, where grade *Y* = grade *X* + 1; fertility rate is the number of births per 1,000 women ages 15–44.

a. Because of the two-year lag in reporting of births in Minnesota, this value was unavailable in 2013. Therefore the number of women of child-bearing age in the prior year (that is, the number of women ages 15–44 in 2011 multiplied by the most recent fertility rate divided by 1,000) was used.

b. Because of the two-year lag in reporting births in Minnesota, neither the number of births in 2013 nor the number of women ages 15–44 in 2012 was available. Therefore the number of women ages 15–44 in 2012 was estimated using the size of the same cohort five years prior (that is, the number of girls and women ages 10–39 in 2007).

Source: Authors' literature review of methodologies for making enrollment forecasts.

Table A3. Sample calculations for 10-year forecasts from 2013/14 school year

Grade in 10 years	Status of cohort in 2013/14	Calculations for 10 year forecasts to 2023/24 school year
12	Grade 2	Number of students in grade 2 in 2013/14 * GPR_{2-3} * GPR_{3-4} * GPR_{4-5} * GPR_{5-6} * GPR_{6-7} * GPR_{7-8} * GPR_{8-9} * GPR_{9-10}* GPR_{10-11} * GPR_{11-12}
11	Grade 1	Number of students in grade 1 in 2013/14 * GPR_{1-2} * GPR_{2-3} * GPR_{3-4} * GPR_{4-5} * GPR_{5-6} * GPR_{6-7} * GPR_{7-8} * GPR_{8-9} * GPR_{9-10} * GPR_{10-11}
10	Kindergarten	Number of students in kindergarten in 2013/14 * GPR_{K-1} * GPR_{1-2} * GPR_{2-3} * GPR_{3-4} * GPR_{4-5} * GPR_{5-6} * GPR_{6-7} * GPR_{7-8} * GPR_{8-9} * GPR_{9-10}
9	Born in 2009	Number of children born in 2009 * BKR * GPR_{K-1} * GPR_{1-2} * GPR_{2-3} * GPR_{3-4} * GPR_{4-5} * GPR_{5-6} * GPR_{6-7} * GPR_{7-8} * GPR_{8-9}
8	Born in 2010	Number of children born in 2010 * BKR * GPR_{K-1} * GPR_{1-2} * GPR_{2-3} * GPR_{3-4} * GPR_{4-5} * GPR_{5-6} * GPR_{6-7} * GPR_{7-8}
7	Born in 2011	Number of children born in 2011 * BKR * GPR_{K-1} * GPR_{1-2} * GPR_{2-3} * GPR_{3-4} * GPR_{4-5} * GPR_{5-6} * GPR_{6-7}
6	Born in 2012[a]	Number of women ages 15–44 in 2011 * $\frac{\text{Fertility rate in 2011}}{1{,}000}$ * BKR * GPR_{K-1} * GPR_{1-2} * GPR_{2-3} * GPR_{3-4} * GPR_{4-5} * GPR_{5-6}
5	To be born in 2013[b]	Number of girls and women ages 10–39 in 2007 * $\frac{\text{Fertility rate in 2011}}{1{,}000}$ * BKR * GPR_{K-1} * GPR_{1-2} * GPR_{2-3} * GPR_{3-4} * GPR_{4-5}
4	To be born in 2014[b]	Number of girls and women ages 10–39 in 2008 * $\frac{\text{Fertility rate in 2011}}{1{,}000}$ * BKR * GPR_{K-1} * GPR_{1-2} * GPR_{2-3} * GPR_{3-4}
3	To be born in 2015[b]	Number of girls and women ages 10–39 in 2009 * $\frac{\text{Fertility rate in 2011}}{1{,}000}$ * BKR * GPR_{K-1} * GPR_{1-2} * GPR_{2-3}
2	To be born in 2016[b]	Number of girls and women ages 10–39 in 2010 * $\frac{\text{Fertility rate in 2011}}{1{,}000}$ * BKR * GPR_{K-1} * GPR_{1-2}
1	To be born in 2017[b]	Number of girls and women ages 10–39 in 2011 * $\frac{\text{Fertility rate in 2011}}{1{,}000}$ * BKR * GPR_{K-1}
K	To be born in 2018[c]	Number of girls and women ages 5–34 in 2007 * $\frac{\text{Fertility rate in 2011}}{1{,}000}$ * BKR

Note: BKR is birth-to-kindergarten ratio; GPR_{X-Y} is grade-progression ratio from grade *X* to grade *Y*, where grade *Y* = grade *X* + 1; fertility rate is the number of births per 1,000 women ages 15–44.

a. Because of the two-year lag in reporting of births in Minnesota, this value was unavailable in 2013. Therefore the number of women of child-bearing age in the prior year (that is, the number of women ages 15–44 in 2011 multiplied by the most recent fertility rate divided by 1,000) was used.

b. Because of the two-year lag in reporting births in Minnesota, neither the number of births this year nor the number of women ages 15–44 in the prior year was available. Therefore the number of women ages 15–44 was estimated using the size of the same cohort five years prior (for example, the number of girls and women ages 10–39 in 2007 was used to estimate the number of women ages 15–44 in 2012).

c. Because of the one-year lag in reporting census data, the estimate for the number of girls and women ages 10–39 in 2012 was not available in 2013. Therefore the number of women ages 15–44 in 2018 was estimated using the size of the same cohort 10 years prior to the birth year (that is, the number of girls and women ages 5–34 in 2007).

Source: Authors' literature review of methodologies for making enrollment forecasts.

Notes

1. Minnesota has a number of certification mechanisms that are collectively called special permissions here. They include personnel variances, limited certificates, certificate waivers, community expert certificates, and nonrenewable certificates. Most states have similar types of certificates for individuals to teach topic areas and grade levels for which they are not certified; names for these certificate types vary by state.
2. The data on special permissions were deemed valid and reliable because the Minnesota Department of Education and the Minnesota Board of Teaching enforce the certification rules and requirements. Comparable data are likely available in other states as well. The district survey contained survey items asking district leaders to indicate the level of difficulty they experienced hiring teachers in various topic areas over the past two years and the amount of difficulty they expected to experience hiring teachers in those areas of certification in the coming years. As measures of district leaders' perceptions, these data were considered by the technical assistance team to be less reliable indicators of teacher shortages than were the data on special permissions. However, when the technical assistance team analyzed these data, the findings were consistent with areas of shortage identified in the data on special permissions.
3. See appendix F in Minnesota Department of Education (2015) for details of the forecast model testing.
4. See Minnesota Department of Education (2015) for copies of the surveys.
5. A detailed description of steps in data cleaning, preparation, and analysis is beyond the scope of this report. The technical assistance team provided such details to the Minnesota Department of Education.
6. In Minnesota, birth data are not provided for units smaller than the county. Thus the grade-progression ratio forecast model cannot be used for forecasting at the district or school levels.
7. For example, the grade-progression ratio for grades 3 and 4 between 2012/13 and 2013/14 is $\frac{\text{Grade 4 enrollment in 2013/14}}{\text{Grade 3 enrollment in 2012/13}}$.
8. For example, the birth-to-kindergarten ratio for the cohort of births in 2004 can be calculated as $\frac{\text{Number of students in kindergarten in 2009/10}}{\text{Number of children born in 2004}}$.

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