An Analysis of Secondary Mathematics Teacher Retirement in Kansas

Steven B. Case

Steven Obenhaus

Center for Science Education

University of Kansas

EDUCATION INFORMATION

 The University of Kansas Center for Science Education (CSE) was established in Fall 2000 based on a recommendation from the Task Force on Science Education appointed by Chancellor Robert Hemenway. The CSE is an interdisciplinary collaborative venture intended to improve science education at KU and throughout the state of Kansas while contributing to scholarship in science education on a national and international level. CSE activities involve scientists, science educators and education specialists from many units on the Lawrence campus including the College of Liberal Arts and Sciences, the School of Education, the School of Engineering, the Center for Teaching Excellence, the Center for Research on Learning, and the Natural History Museum & Biodiversity Research Center. KU CSE produces data-based reports designed to inform and give direction to the Center's research and mission.

The authors wish to thank their friends and colleagues at the Center for Science Education for their reviews and advice; Margie Hill, Brad Williamson, Wendy Elkins, Edith Eskilson, Carol Williamson, Sarah Delgado, Danielle Baker, Billie Archer and Kristi Parfet.

Center for Science Education, Dole Human Development Center, University of Kansas, 1000 Sunnyside Avenue, Room 3078, Lawrence, KS 66045-7555, ph. 785-864-4471

Web sites: http://www.kuscied.org and http://ukanteach.ku.edu

If the United States is to remain competitive in the 21st century, it is imperative that its citizens – and its students - be proficient in mathematics. The overall state of school-based mathematics learning has been at the forefront of discussions about national education since the publication of *A Nation at Risk* (1983). That report placed a national spotlight on American students' ongoing dismal performance in mathematics. In spite of this increased attention, students have gained little ground since then. *A Nation Accountable* (2008) asserts that "our performance at the high school level is as alarming now as it was at the time of *A Nation at Risk*, if not worse." American school children continue to perform so poorly on standardized tests of mathematics achievement that they often come in near the bottom of rankings that compare them with students from other industrialized countries (PISA 2009, TIMSS, 2007).

In 2002 Congress passed the No Child Left Behind (NCLB) Act as a reauthorization of the Elementary and Secondary Education Act. NCLB was intended to address the poor performance of students by bringing about significant changes to schools, particularly in reading and mathematics. NCLB requires that states implement annual assessments that are directly tied to state-developed academic standards, which, in this case, define what every student is required to know in mathematics. Based on these academic standards, states were charged with developing more rigorous mathematics curricula aligned with state and local mathematics content standards and assessments. These assessments began driving the teaching processes.

As a result of the NCLB legislation, it has become common practice to evaluate teachers, schools and districts by looking at changes in their students' test scores. The philosophy behind evaluating teachers in this way assumes that if improvements in student performance are what is valued, teachers should be judged by their students' scores. If the scores go up, the teacher is effective; if they don't go up, the teacher is not effective and should be dismissed. This is quite controversial in the broader education community because teachers are only one variable in student achievement. What's more, there is still no valid way to determine how much of the variation in a test score is due to teacher action. There is also a fundamental problem in how performance or skill is measured, and for what ends. Psychometricians warn that tests should be used only for the purposes for which they were intended, and nothing more. In other words, a test of fifth grade mathematics assesses whether students in the fifth grade are able to perform mathematical tasks appropriate for their age. It cannot then be used to determine whether the students' teacher was good or bad.

Getting lost in the controversy surrounding the measurement of teacher efficacy are the learners. In a partial response, a new common core of mathematic standards has been developed that strives to re-center mathematics education on the learner rather than the teacher. The Common Core Standards define what students should understand and be able to do in their study of mathematics. They are common because most states are adopting these standards, instead of each state developing its own set of standards and criteria. The standards set grade-specific content mastery expectations, but do not define the intervention methods or materials necessary to support students who are well below or well above grade-level expectations. In addition, the "sequence of topics and performances" outlined in a body of mathematics standards must also respect what is known about how students learn. Assessing the coherence of a set of standards is more difficult than assessing its overall focus. As Confrey (2007) points out, developing "sequenced obstacles and challenges for students…absent the insights about meaning that derive from careful study of learning, would be unfortunate and unwise." One characteristic of mathematical understanding is a learner's ability to justify, in a way appropriate to the student's mathematical maturity, why a particular mathematical statement is true. Students should also have a deep understanding of where a mathematical rule comes from. In this context, mathematical understanding and procedural skill are equally important and both are assessable.

The changes in standards, curriculum, assessment and instruction in mathematics are being driven by somewhat different understandings of mathematical literacy. Mathematics literacy needs to be defined in a way that makes what needs to be measured completely clear. Many definitions of mathematics literacy give explicit attention to number, arithmetic, and quantitative situations. For example, one definition describes math literacy as "The knowledge and skills required in applying arithmetic operations, either alone or sequentially, using numbers embedded in printed material (e.g., balancing a checkbook, completing an order form)" (NCES 1993). Many other definitions include a variety of skills, knowledge, beliefs, dispositions, habits of mind, communication capabilities, and problem solving skills that people need in order to engage effectively in quantitative situations arising in life and work. These definitions are fundamentally limited by their emphasis on *quantity*. The definition of mathematical literacy should not be restricted to the ability to apply quantitative aspects of mathematics. It should involve knowledge of mathematics in its broadest sense. Such a wider definition of mathematical literacy is provided by the PISA (2003), which says, "Mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen." This definition of mathematical literacy includes understanding skills such as general spatial awareness and determining spatial relationships, interpreting graphical visualizations and map reading, interpretation of data resulting in all kinds of models and visualizations (Freudenthal 1973), (Tufte1983, 1990, 1997)

While many would agree math literacy is not only desirable but essential, productive discussions of math literacy are severely hampered by multiple problems. Not only is there a lack of consensus on what constitutes math literacy; there is also a lack of consensus on how to achieve it. In addressing this issue, many of the previously cited reports stress a growing need for highly qualified teachers, particularly in mathematics and sciences, in order to develop a citizenry able to fully participate in an increasingly complex, technology-driven society. There is increasing agreement among researchers and educators that classroom teachers are perhaps the most critical factor in improving student academic achievement. According to Treffers (1991), the high level of innumeracy does not result from what content is taught or not taught, but from the structural design of teaching practices. While assessments should focus on student learning, the desired level of student learning will not be reached unless the need for high-quality instruction is also addressed.

One of the most basic questions a society can address is: who will teach the children? School districts all around the United states report difficulty in recruiting and retaining sufficient numbers of highly skilled teachers trained in science, technology, engineering and mathematics (STEM) content and teaching pedagogy. Schools obviously have a need for these kinds of highly qualified mathematics teachers; their needs are compounded by the increasing incidence of layoffs within the teaching workforce. It seems counter-intuitive that the national move toward teacher layoffs is occurring at the same time that many policy-makers and business people are expressing a great need for highly qualified teachers. And yet, the trend toward layoffs and retirement continues. Thus, those engaged in mathematics teacher preparation are faced with answering some very basic questions about teaching and teacher distribution. How many new teachers should be produced each year to meet the needs of school districts? Is there really a shortage of highly-qualified secondary mathematics teachers? Will there be jobs available for graduates that are prepared to start their teaching career? If there are teaching jobs, will they be where students want to live?

The operational definition of a shortage must include the notion that a shortage exists when too few persons with the required qualifications offer their services for the available openings (Rumberger, 1985). Determining an absolute value of teacher shortages as a function of unfilled positions is very difficult. When students are sitting in a classroom, there is always at least one adult in the role of teacher. Whether or not that that adult can effectively teach the content is a separate and often unanswered question. Depending on their size, schools and districts have a variety of adjustments that can be made to schedules, class sizes, and hiring standards in order to fill vacancies. These adjustments can allow districts to meet their unique staffing requirements (Haggstrom et al., 1988). However, despite the districts' best efforts to maintain staff, there is evidence indicating that shortages of qualified math and science teachers have existed for most of the last 30 to 40 years (Kershaw & McKean, 1962; Levin, 1985; Collins & Gillespie, 2009).

Where a teacher shortage occurs is an equally important component of the problem. Shortages may be a local issue in districts that do not have access to a pool of highly-qualified applicants. This is particularly true in states with a high number of rural school districts that are far from urban centers and far from teacher preparation programs (U.S. Department of Education, National Center for Education Statistics, 2009). These districts have low numbers of students and limited numbers of teachers. The loss of a single teacher may create a shortage in these districts. Critical shortages can occur when a highly-qualified mathematics teacher cannot be recruited to fill a local teaching position.

It is difficult to determine how many math teachers are needed. Ingersoll and Perda (2009) argue that retirement is not a significant variable in teacher shortages when they state:

> The data show that there are indeed widespread school staffing problems—that is, many schools experience difficulties filling their classrooms with qualified candidates, especially in the fields of math and science. But, contrary to conventional wisdom, the data also show that these school staffing problems are not solely, or even primarily, due to shortages in the sense that too few new mathematics and science teachers are produced each year. The data document that the new supply of mathematics and science teachers is more than sufficient to cover the losses of teachers due to retirement.

In their view, the revolving door of secondary mathematics teaching is created by challenging working conditions and the pay gap between mathematics teaching and other employment opportunities for those trained in mathematics. As has been the case for quite a while, the math and science fields both experience the highest teacher turnover rate among all content disciplines (Murnane et al., 1991). Retirement is a minor variable in teacher turnover.

Given idiosyncratic difficulties in determining actual shortages and an ill-defined need for additional secondary mathematics teachers, teacher retirement could serve as a baseline for the production of new teachers. This work uses Kansas as a case study to understand the extent and location of mathematics teacher retirement across the school districts of Kansas.

Kansas Secondary Mathematics Teacher Data (2009-2010)

The total student enrollment for the state of Kansas is 473, 772. Of these, 258,531 are secondary students (grades 6-12). These students are in 290 Kansas school districts, each of which offers all of the secondary grade levels. The number of secondary mathematics teachers in each district ranges from 1 to 306 (mean: 9.25, median: 4, mode: 3) for a total Kansas mathematics teaching workforce of 2691. This number includes all teachers who taught at least one section of mathematics during the school day (2009-2010 school year). The statewide average age of secondary mathematics teachers is 42.4 years with 13.2 years of teaching experience, establishing a median combined age and experience of 55.6 years.

Kansas teachers are eligible for retirement when their combined age and years of experience total 85. An alarming statistic that quickly emerges from analysis of the data is that currently, 321 secondary mathematics teachers are currently teaching over the retirement threshold of 85 – meaning that 12% of the secondary mathematics teachers are in this situation. 46 of these teachers are over the age of 65. Along with the 321 mathematics teachers currently eligible to retire, an additional 1108 will reach the threshold for retirement in 15 years. Statewide mathematics teacher data further indicate:

- An average of 73 secondary math teachers will be eligible to retire each year through 2030 (Figure 1).
- 569 secondary math teachers 21% will be eligible to retire over the next five years.

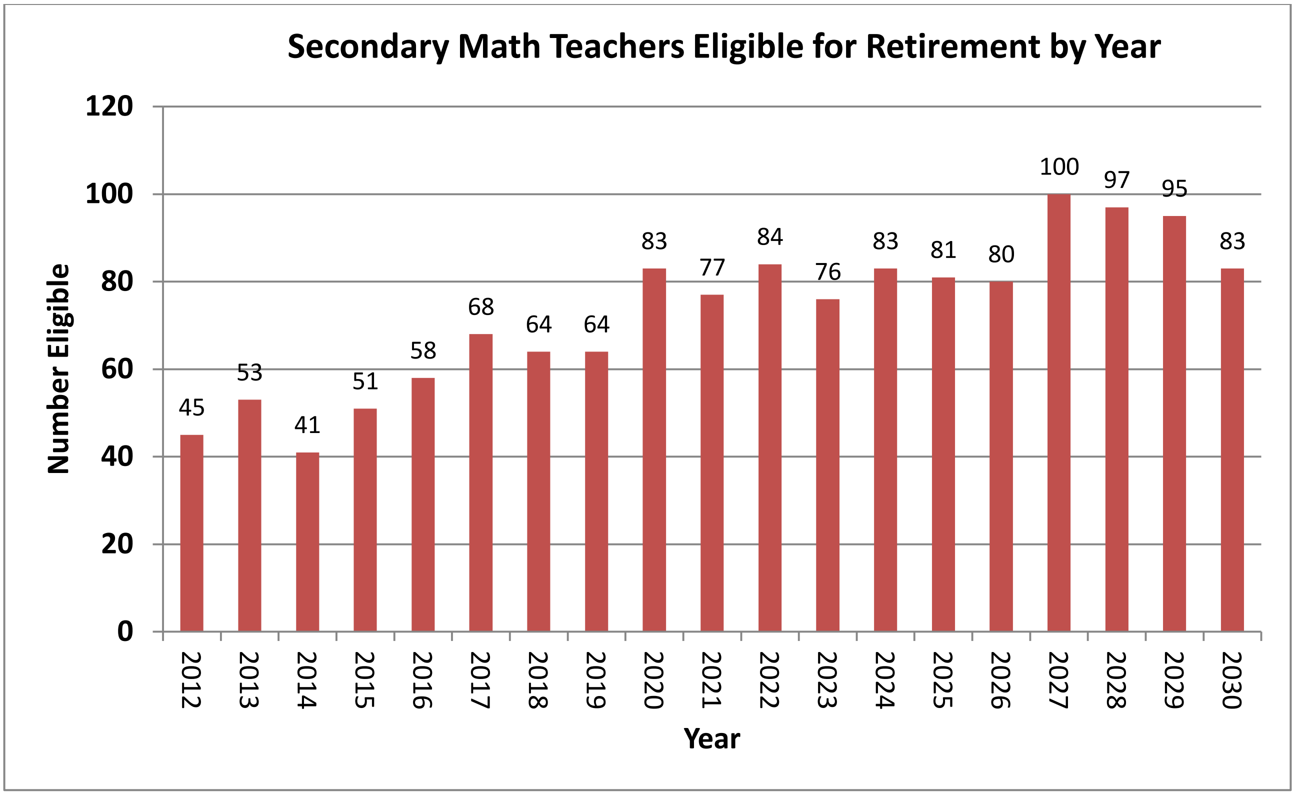

Figure 1: Secondary Mathematics teachers who will become eligible for retirement by year.

In a large and predominantly rural state, it is important to determine the regions in which shortages of secondary mathematics teachers may be occurring. Because teacher preparation most commonly consists of completing a four year program before the teacher is prepared to teach, it is equally important to predict where future shortages will occur. Using geographic analysis to look statewide at school districts, a *risk-for-retirement* scale was applied to the mathematics teaching workforce of each school district (Figure 2). The index established that if 40% of the mathematics teachers in a district were eligible to retire, then that district is placed in the high risk category (red). If 21% – 40% of mathematics teachers can now retire, then that district is at moderate risk. When 21% or fewer of a district's mathematics teachers are eligible for retirement, the school district is placed in the minimal risk category.

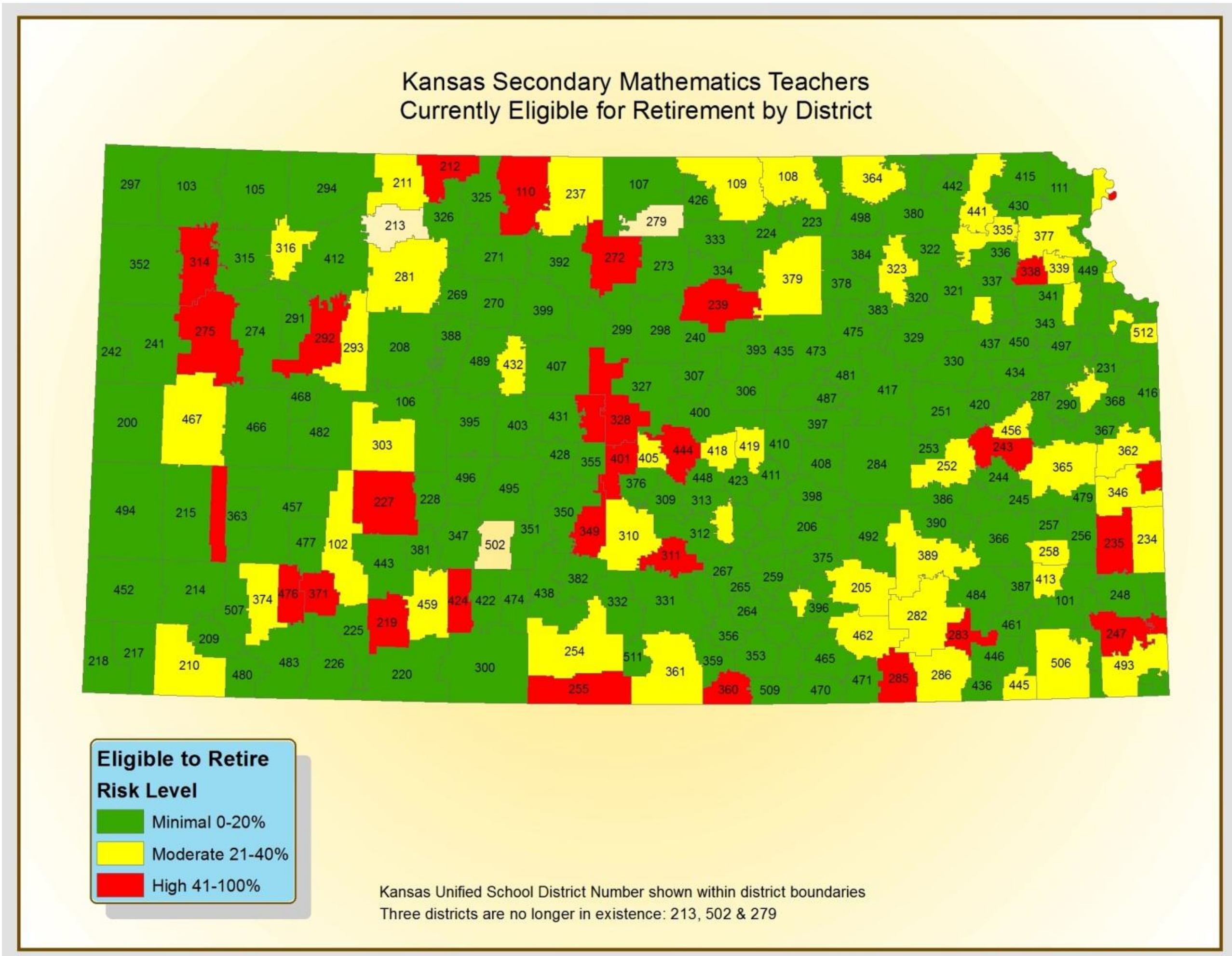

Figure 2: Current eligibility for retirement for secondary mathematics teachers

While no clear geographic patterns emerge from the map, it is clear that potential retirements are widespread. The 29 red districts that have more than 40% of their mathematics teachers immediately eligible to retire (Figure 2) are dispersed across the state. One in ten districts is currently at high risk of losing a large portion of their mathematics teacher workforce; while an additional two in ten could lose a significant part of their mathematics teacher workforce in the near future. Even for those districts which don't face the risk of imminent mathematics teacher retirements, there are still emerging issues that cause concern. The two maps, represented in Figures 3 & 4, show the five and ten-year progression of potential mathematics teacher shortages resulting from retirement for Kansas school districts. Using the same *risk-for-retirement* scale, projection of the data over the next five years indicates that 39 districts could lose half of their mathematics teachers or more (Figure 3). Most of these are smaller, somewhat rural school districts, although the state’s larger districts are at moderate risk for losing 21% to 40% of their mathematics teachers over the same time period. These projections show that most districts in Kansas will find themselves needing to replace a significant number of their mathematics teachers destined to permanently leave the workforce due to retirement.

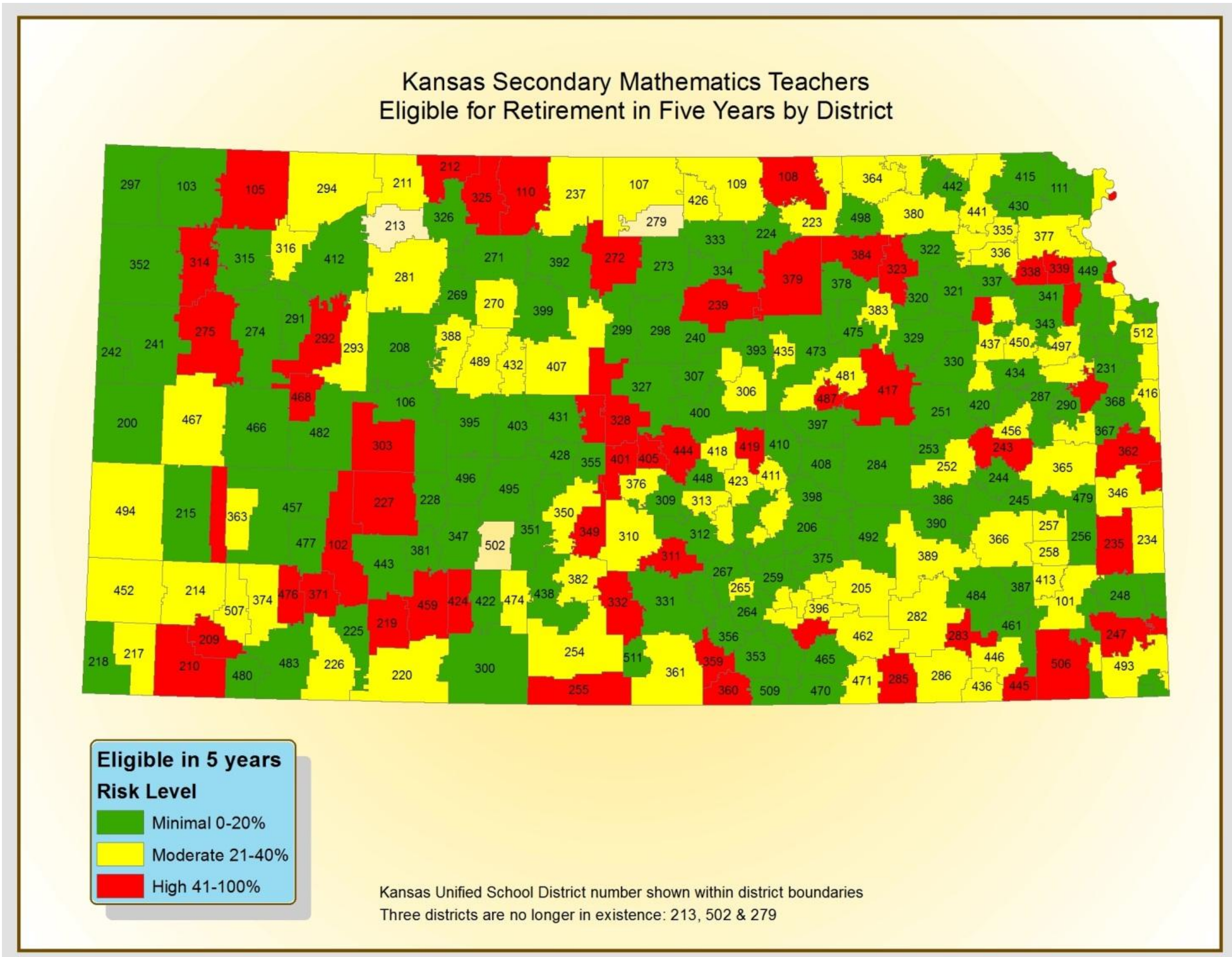

Figure 3: Eligibility for retirement of secondary mathematics teachers over the next five years.

The response of Kansas teacher preparation programs in creating new mathematics teachers in response to this retirement data cannot be immediate. Undergraduate teacher preparation programs in the state are four-year programs. The need for highly qualified mathematics teachers will continue to grow during the four years needed to prepare the new teachers. The retirement data, however, can establish a target for the level necessary for new mathematics teacher production. Figure 4 shows the statewide distribution of secondary mathematics teachers that will become eligible for retirement over the next ten years. Looking five and ten years down the road (Figures 3 & 4) the increasing number of red districts shows the likelihood that many of the state's districts will need to replace over half their mathematics teachers within the coming decade. In fact, these 89 red districts represent about a third of the total 290 school districts in Kansas.

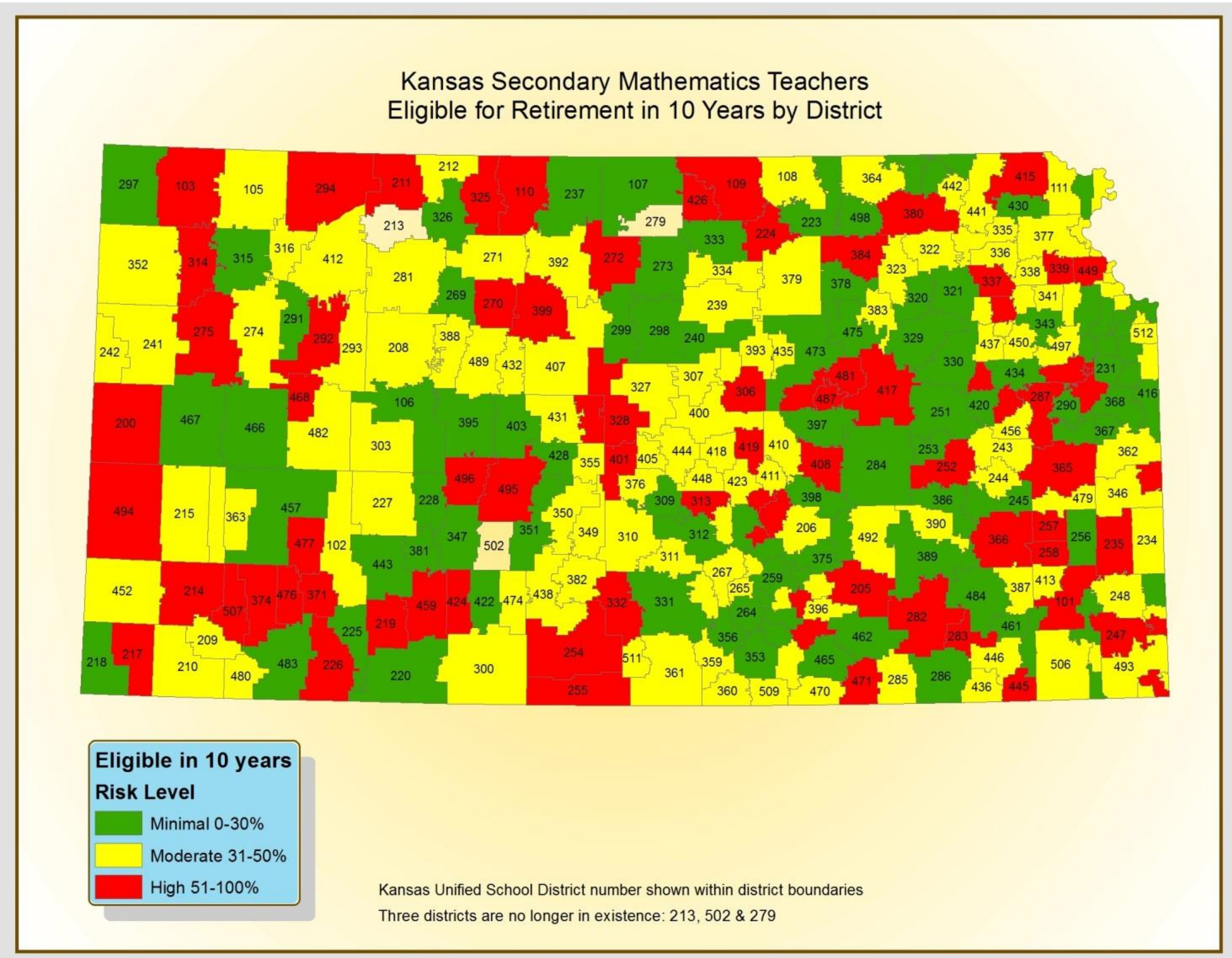

Figure 4: Eligibility for retirement of secondary mathematics teachers over the next ten years.

While potential shortages are widespread, similarities among these districts emerge when the relative population densities of each district are taken into account. The U.S. Department of Education divides all school districts in the country into one of four broad categories: city, suburban, town or rural. According to this classification, Kansas has 7 city districts, 9 suburban districts, 65 town districts and 210 rural school districts. Table 1 shows the number of mathematics teachers according to the type of district in which they work. The first column is the number of teachers who are eligible to retire now at the previously discussed 85 threshold. Rural districts have the highest proportion of their mathematics teacher workforce currently eligible to retire (17.5%) followed closely by town districts (17.1%.) This means the vast majority of Kansas school districts (275 out of 291) face the prospect of replacing more than 1 out of every 6 of their mathematics teachers due to retirement.

	Mid and Early Career	Eligible to Retire	Percent Eligible
City Districts	621	45	6.8%
Suburban Districts	307	49	13.8%
Town Districts	659	103	13.5%
Rural Districts	783	124	13.7%

Table 1: Mathematics teachers by district classification

In this analysis, we chose to use secondary mathematics teacher data (2009-2010) so that we could understand a specific component of the teaching workforce. General teacher workforce statistics are not very helpful in predicting changes within specific subgroups of teachers. In this case study, the specific subgroup of teachers is defined as those who teach at least one class section of secondary mathematics. Separating teachers by discipline allows for analysis of workforce variables specific to that particular subgroup. As previously mentioned, it is important to understand that retirement is not the primary reason that secondary mathematics teachers leave teaching.

The Kansas economy requires well-prepared citizens and workers in Science, Technology, Engineering and Mathematics (STEM). Wichita, Kansas manufactures 70% of the world's general aviation aircraft. The Kansas City metropolitan area is a center of automobile production and printing. Metal fabrication, printing, and mineral products industries predominate in the nine southeastern counties of Kansas, and Kansas continues to lead the nation in agricultural production. Scientists and engineers are innovators in their fields, fueling energy, biotechnology, manufacturing, aviation and agricultural industries that drive our region’s economic engine. Their impact throughout the region is invaluable.

This study is the second study in a series that looks at the science and mathematics teaching workforce in Kansas. It is clear the preparing the next generation with appropriate skills for the Kansas STEM workforce requires high quality math and science education in our schools. These studies do not look at the quality of instruction, but only explore the potential for retirement of the STEM teaching workforce. Figure 5 (below) combines the retirement eligibility for the mathematics and science teachers in Kansas. These numbers, combined with the knowledge that retirement is but a minor variable in teacher turnover, should set off alarm bells for policy-makers.

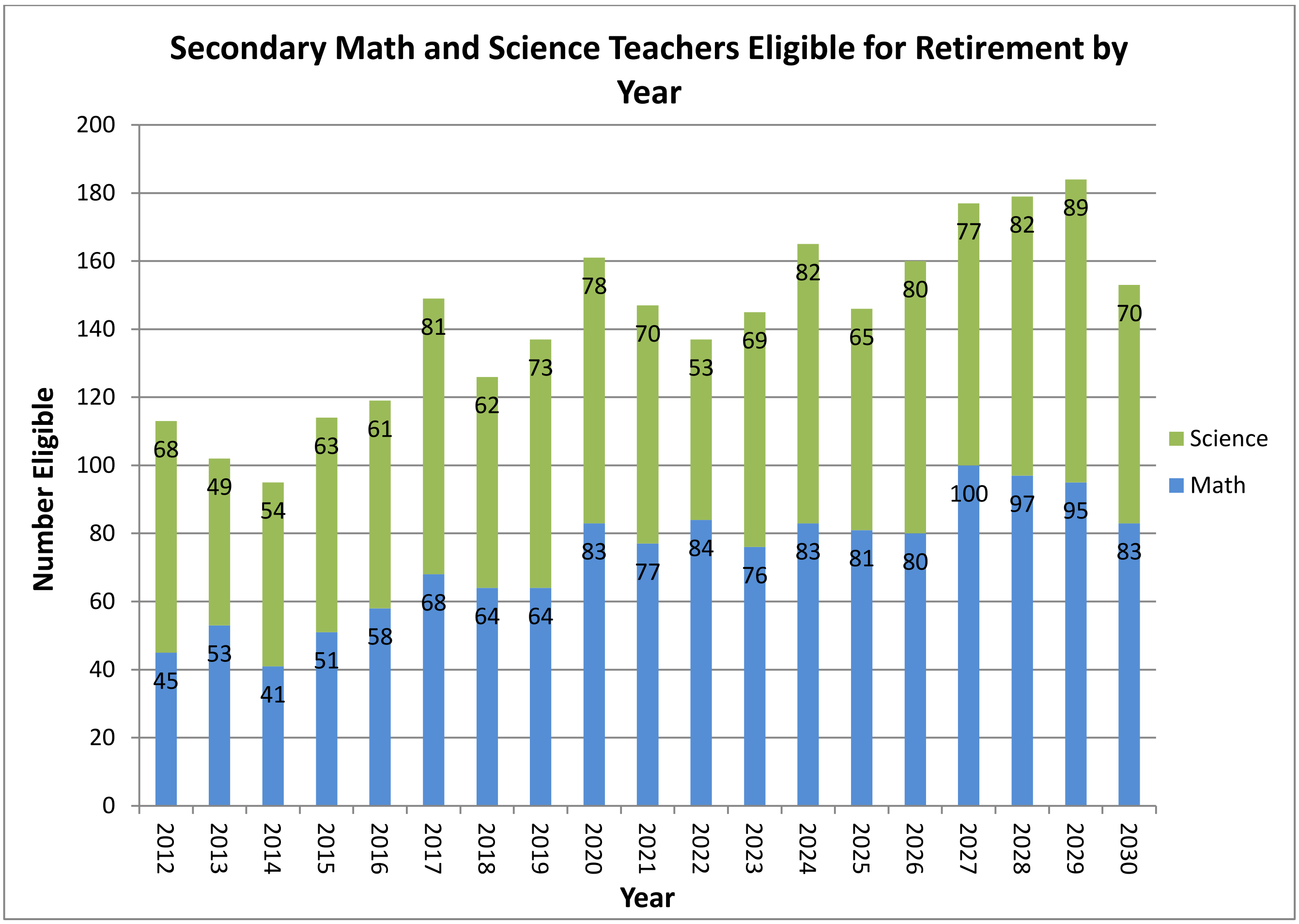

Figure 5: Combined secondary mathematics and science teachers who will become eligible for retirement by year.

Teacher retirements in Kansas provide a relatively consistent target for new teacher production, since the individuals who do retire will leave the workforce and not return. Retirement numbers can provide useful guidance for STEM teacher preparation programs for the necessary production of new mathematics and science teachers. An understanding of the geography of the teacher workforce is also critical. Teacher shortages are often a local issue. In responding to the loss of a secondary mathematics teachers, a small and rural district will have special challenges in both attracting and retaining a replacement mathematics teacher. The Kansas secondary mathematics teacher data reflects the potential for geographically widespread teacher shortages over the next ten years as a result of retirement. Specific policies and programs need to be developed that address a variety of specific local needs. This will ensure that all students continue to have availability to high-quality teaching and discipline-prepared mathematics teachers across the State. It is hoped that the insights that can be gleaned from this state level case study will inform all stakeholders on the actual needs of local communities.

References

Collins A. & Gillespie, N. (Eds.) 2009, *The continuum of secondary science teacher preparation; Knowledge, questions, and research recommendations***,** Knowles Science Teaching Foundation Moorestown, New Jersey

Confrey, J. (2007) *Tracing the Evolution of Mathematics Content Standards1 in the United States: Looking Back and Projecting Forward***,** A paper prepared for the Conference on K-12 Mathematics Curriculum Standards February 5-6,2007, Sponsored by CSMC, NCTM, Achieve, College Board, MAA, ASA.

(Freudenthal 1973), Mathematics As an Educational Task, D. Reidel Publishing Company, Dordrecht-Holland.

Gardner,D. (1983). *A Nation at Risk: The Imperative for Educational Reform*. Report of the National Commission on Excellence in Education.Washington, DC:Government Printing Office.PISA 2009,

Gonzales, P., Williams, T., Jocelyn, L., Roey, S., Kastberg, D., & Brenwald, S. (2008). Highlights from TIMSS 2007: Mathematics and science achievement of U.S. fourth- and eighth-grade students in an international context. Washington, DC: U.S. Department of Education. Collins & Gillespie, 2009

Ingersoll, R.M. and Perda, D. (2010). Is the Supply of Mathematics and Science Teachers Sufficient? *American Educational Research Journal*. Vol. 43(3). pp. 563-594.

Ingersoll, R., & Perda, D. (2009). The mathematics and science teacher shortage: Fact and myth. The Consortium for Policy Research in Education. Retrieved January 26, 2010, from http://www.cpre.org/images/stories/cpre_pdfs/math%20science%20shortage%20paper%20march%202009%20final.pdf

Kershaw, Joseph A., and Roland n. McKean, 1962. Teacher Shortages and Salary Schedules. New York: McGraw-Hill.Haggstrom et al., 1988

Levin ,Henry M. Solving the Shortage of Mathematics and Science Teachers, *Educational Evaluation and Policy Analysis*, Vol. 7, No. 4 (Winter, 1985), pp. 371-382

Murnane, R., Singer, J., Willett. J., Kemple, J., & Olsen, R. (Eds.). (1991). *Who will teach?: Policies that matter*. Cambridge, MA: Harvard University Press.

Rumberger, R. (1985). The shortage of mathematics and science teachers: A review of the evidence. Educational evaluation and policy analysis, 7(4), 355- 369.

Tufte, E., 1983, *The Visual Display of Quantitative Information*. Cheshire, CT: Graphics Press. (2001, 2nd edition, ISBN 0961392142).

Tufte, E., 1990. *Envisioning Information*. Cheshire, CT: Graphics Press. ISBN 0961392118.

Tufte, E., 1997. *Visual Explanations: Images and Quantities, Evidence and Narrative*. Cheshire, CT: Graphics Press. ISBN 0961392126.

U.S. Department of Education, National Center for Education Statistics (2009). Percentage of public elementary and secondary schools with a teaching vacancy in selected teaching fields, by the school's reported level of difficulty in filling the vacancy, teaching field, and locale: 2007–08. Retrieved August 17, 2011, from http://nces.ed.gov/surveys/ruraled/tables/c.1.c.-1.asp

U.S. Department of Education (2008). A Nation Accountable: Twenty-five Years after "A Nation at Risk", United States Department of Education, Washington, DC, available at: www.ed.gov/rschstat/research/pubs/accountable/accountable.pdf