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ENSURING MATHEMATICAL LEARNING IN RURAL SCHOOLS

Investing in Teacher Knowledge

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ABSTRACT—In this research article we share our vision of how to improve student mathematics success in rural districts. Good teaching matters. We have found two recurring features that can support teachers' success in effectively teaching students mathematics: high-quality, longitudinal professional development and professional connections. We partner with rural districts and master teachers to offer local high-quality professional development for mathematics teachers to strengthen their mathematical knowledge for teaching. We have substantial evidence that participation in longitudinal, high-quality professional development significantly increases teachers' mathematical knowledge for teaching, as well as improves their confidence in teaching. Bringing teachers together for professional development helps teachers develop professional connections. Such connections are necessary for teachers to have regular conversations about mathematics teaching and learning with peers. University-district partnerships can provide infrastructure to allow teachers to develop connections with each other, to collectively support each other, and to collaborate in teaching mathematics more effectively. Investing in professional development for rural teachers and supporting professional connections among teachers will help us achieve the common goal of increasing student success in mathematics.

Key Words: mathematics teachers, rural education, mathematical knowledge for teaching, professional development, teacher retention

INTRODUCTION

A worthy goal for any K–12 school district is to provide students with an educational environment in which all (or almost all) students graduate from high school and are ready for a career or college. How can school districts accomplish this goal? In particular, how do rural school districts accomplish this goal? More specific to the topic

of this article, how do we ensure high quality mathematics learning in rural schools? And what role could university-based mathematicians and mathematics educators working in collaboration (Heaton and Lewis 2011) to support K–12 mathematics teaching and learning in Nebraska play in the process?

We have a simple thesis. Good teachers matter (Darling-Hammond 1997; Wenglinsky 2002). Although there are certainly many other aspects of schools and schooling

that are important, if our educational systems are to be successful at educating the youth of our state, the single most important variable is the quality of teaching in our schools. Good teaching is also quite difficult, and the challenges are exacerbated when teachers are physically isolated from peers.

Our focus, for the purpose of this article, is on the people who teach mathematics in rural schools within Nebraska. How do rural school districts staff their schools with outstanding mathematics teachers, both strong in their knowledge of the disciplines they teach and current with respect to the knowledge of teaching and students that enables them to transfer what they know into learning in their classrooms? This is an important question to ask at a time when there are major shortages in science, technology, engineering, and mathematics (STEM) teachers (Ingersoll and Perda 2010); a limited number of teachers willing to work long-term in rural areas (Storey 1993; Campbell and Yates 2011); and a need for high-quality teachers (Darling-Hammond 2006).

RECRUITING RURAL TEACHERS

A possible hypothesis for dealing with the need for high quality teachers is that rural districts must pay their teachers better to compete for the most outstanding graduates of the state's teacher education programs. We will leave it to others to discuss whether rural districts have the capacity to pay higher salaries, but the evidence is strong that rural districts do not offer salaries that are competitive with urban and suburban districts, and "[a]verage salaries influence both recruitment and retention decisions" (Miller 2012, 20).

In examining the publicly available 2012–13 salary schedules for Nebraska (collected annually by the Nebraska State Education Association, <http://www.nsea.org/compensation>), most rural districts have salary schedules beginning at \$28,000–30,000, with 4–6 horizontal steps (such as BA+18, BA+36, MA, and MA+18) and 11–18 vertical steps (years of experience); salaries top out around \$48,000–55,000. For example, Elba has a starting salary of \$28,280 and Elm Creek starts teachers at \$30,925. In the larger communities salaries start at \$34,000–38,900 (for example, Omaha starts teachers at \$34,196, and Lincoln starts them at \$38,849), have horizontal steps that go up to the PhD degree, and 20–30 vertical steps that top out around \$68,000–76,800. However, as Monk (2007) argues, paying teachers more is not a complete answer. If teachers do not become accepted as rural community members or if they are not able to find satisfying social and recreational opportunities (Storey 1993), they will not

remain in rural communities as teachers no matter how much money they are paid.

Nationwide over 60% of teachers work within 20 miles of where they attended school, compared to 42% of college graduates in general (Reininger 2012). Many others return to teach in the community where they grew up or in a community to which they are attracted for personal or family reasons. Teachers show a strong preference for teaching in a school similar to the K–12 schools they attended (Boyd et al. 2005). Thus, while it can be difficult for rural schools to attract teachers who grew up in urban or suburban communities, rural districts are likely to be successful in attracting and retaining local teachers or teachers who "experienced some level of education in the country" (Campbell and Yates 2011, 9).

Indeed, rural districts might consider a plan to "grow their own" (Skinner et al. 2011) by encouraging community members to become teachers and then return to teach in their community. Additionally, Boyd et al. (2011) support the notion that rural schools are attractive to some teachers due to the autonomy they offer teachers. Hellsten et al. (2011) cite teachers' need for community and connection as a main factor in keeping teachers in rural schools. These are two factors that can be affected by rural districts in ways that may "encourage capable teachers to remain and to strengthen their commitment to teaching in the rural community" (Storey 1993, 168).

INVESTING IN RURAL MATHEMATICS TEACHERS

Given what is known about workforce demographics, rural districts are likely to have more success if their own community members become teachers. Once teachers are hired, the district or principals should strive to ensure that they have opportunities to continue learning and to be part of a formal professional community of teachers supporting one another's professional growth or that teachers participate in other sorts of collaboration (such as instructional planning at faculty meetings or comparison of teaching strategies among peers from different schools or across subject areas) (Howley et al. 2007). Thus, we believe the answer is to invest in the teachers who choose to live and teach in Nebraska's rural communities. Rural districts should want teachers who want to teach in their communities and should find ways to invest in their professional development so that they develop into outstanding master teachers.

The need for professional development is especially important in the area of mathematics. "Mathematics

teaching is an extraordinarily complex activity involving interactions among teachers, students, and the mathematics to be learned in real classrooms” (National Math Advisory Panel [NMAP] 2008, ch. 6, xiii). According to *The Mathematical Education of Teachers II*, “satisfying the minimum requirements for initial certification to teach mathematics does not ensure that even outstanding future teachers have the knowledge of mathematics, of teaching, and of students that is possessed by successful experienced teachers. Like all professionals, teachers need opportunities for professional growth throughout their careers” (Conference Board of the Mathematical Sciences 2012, 18). Moreover, effective professional development that has a measurable impact on teachers’ mathematical knowledge for teaching needs to be sustained over time (e.g., Darling-Hammond 2006).

In multiple studies of student outcomes, the largest single variable is usually the teacher, surpassing even effects of students’ socioeconomic status (e.g., Wenglinsky 2002; NMAP 2008). Additionally there is certain mathematical knowledge that teachers need that other users of mathematics do not (such as figuring out student errors and misconceptions). Unfortunately too many practicing teachers lack sufficient *mathematical knowledge for teaching* to effectively build deep student understanding of mathematics (e.g., Ma 1999; Kilpatrick et al. 2001; Ball and Bass 2003; Ball et al. 2008). By mathematical knowledge for teaching we mean “the particular form of mathematical knowledge that is useful for, and usable in, the work that teachers do as they teach mathematics to their students” (Stylianides and Ball 2008, 308). Teachers with greater mathematical knowledge for teaching are better able to listen to student reasoning and to help students build conceptual understanding of mathematical concepts (e.g., Ball et al. 2008).

Teachers need strong mathematical knowledge for teaching in order to educate students effectively (e.g., Ball et al. 2005; Hill et al. 2005). Loeb et al.’s (2012) research supports teacher professional development as one of the keys to improving education outcomes: “Developing teachers’ skills through professional development may be both the most viable and most effective option for schools looking to improve the quality of their teaching force” (273). Therefore, to improve student outcomes in rural areas, it is important to invest in the professional education of rural mathematics teachers.

PROFESSIONAL DEVELOPMENT EFFORTS

At the University of Nebraska–Lincoln (UNL) we believe we have a shared responsibility to provide mathemat-

ics professional development opportunities statewide to strengthen teachers’ knowledge of mathematics for teaching and pedagogical knowledge, thereby enabling their success. We have a particular commitment to provide these opportunities to rural teachers. For over a decade UNL’s Center for Science, Mathematics and Computer Education (CSMCE) together with the Department of Teaching, Learning and Teacher Education and the Department of Mathematics has focused on improving K–12 mathematics education in Nebraska by working with mathematics teachers statewide. Since 2004 we have been part of teams that secured over \$18,000,000 in National Science Foundation (NSF) grants to provide professional development opportunities for Nebraska teachers and to engage in research that informs Nebraska and the nation as to the benefits of high quality professional development for teachers. With the support of these grants, we have worked with approximately 275 rural Nebraska K–12 teachers. Apart from a small handful of rural teachers who stopped teaching due to family situations, only 2 of these 275 teachers have moved to urban schools, and during the same timeframe 2 urban teachers with whom we worked moved to rural settings. Thus, the retention of these rural teachers is extremely high.

We will focus our discussion on Math in the Middle, a master’s degree program for middle level teachers, Primarily Math, a K–3 mathematics specialist program, and efforts to sustain these opportunities after the end of the NSF grants. Full descriptions of all CSMCE programs and grant-funded activity can be found on our website (<http://scimath.unl.edu/csmce>). The map in Figure 1 shows the distribution of teachers who have participated in our professional development programs over the past decade.

The Math in the Middle Institute Partnership, a 2004–11 Math Science Partnership grant from the National Science Foundation, was an intense master’s degree program targeting middle-level Nebraska mathematics teachers. Math in the Middle had a special focus on working with teachers from rural districts; 89 of the first 125 teachers to earn master’s degrees from the program were from rural Nebraska districts.

Primarily Math is an 18-credit-hour graduate certificate initiative to strengthen mathematics education in the early grades and a major research project designed to inform the nation as to effective strategies to strengthen K–3 mathematics education. By the end of 2014 nearly 300 teachers will have completed the Primarily Math program.

The Nebraska Math and Science Summer Institutes

Math in the Middle, NebraskaMATH and NebraskaNOYCE Teachers by Nebraska Educational Service Units

2010–2011 Teaching Positions for Math in the Middle, 2012–2013 for NebraskaMATH and NOYCE

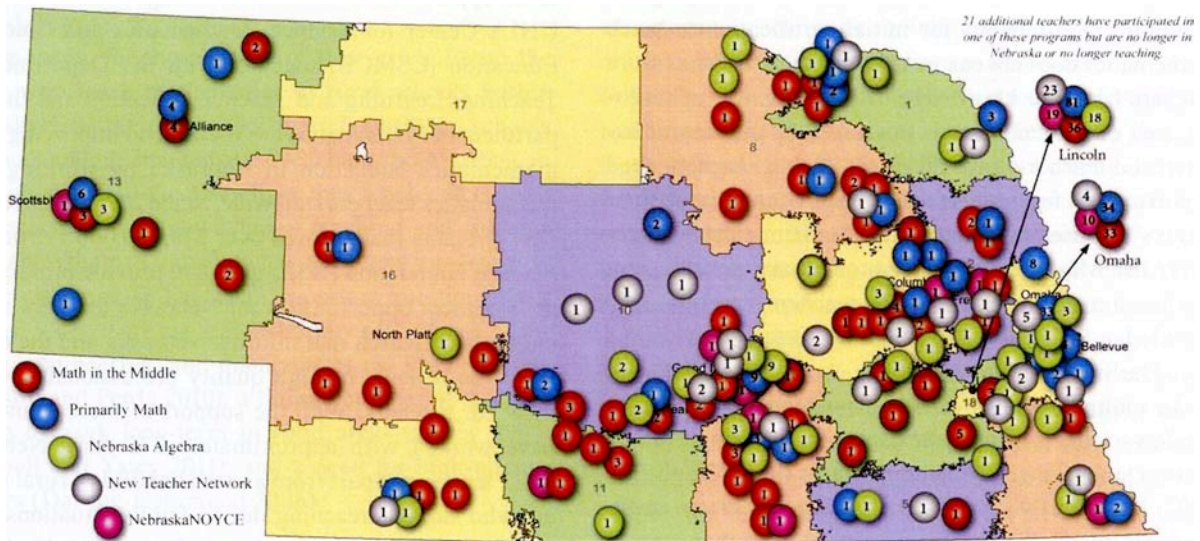


Figure 1. Distribution of teacher participants in CSMCE programs, 2004–12.

(NMSSI) represent an effort to institutionalize the offering of courses developed by the grants. Courses developed by Math in the Middle are now regular offerings of the NMSSI; Primarily Math classes became part of the NMSSI schedule beginning in 2013 as that grant funding comes to an end. Many courses developed for high school teachers also are part of the NMSSI. To better serve rural teachers, each summer NMSSI courses are offered in coordination with Educational Service Units (ESUs) in over a dozen locations across the state.

In both Math in the Middle and Primarily Math, with approval from UNL's Institutional Review Board, we have collected pre-, post- and follow-up survey data from teacher participants using the Survey of Teaching Practices, the Knowledge of Mathematics for Teaching assessment, and a Beliefs/Attitudes survey. In Primarily Math we also collected teacher data from multiple comparison groups—a control group and a group of teachers in buildings with a Primarily Math-trained mathematics coach. In all classrooms of Math in the Middle teachers, in a subset of Primarily Math teachers, and in Primarily Math comparison classrooms, we have administered a fall/spring student assessment; K–3 classrooms also administered a child competence beliefs survey. We also have

collected district- and state-level student testing data, when available, each year since 2003. The research questions of both programs focused on questions related to the basic question Does the program “work”? To what extent are there measurable differences to teachers' mathematical knowledge for teaching, beliefs, and attitudes after participating in a longitudinal professional development program? To what extent can we document an impact on students when their teachers participate in a longitudinal professional development program?

Our approach to offering summer courses is designed with teachers' schedules in mind and with a special sensitivity to the demands on rural teachers who live a significant distance from Lincoln. For some classes 40 hours of instruction is concentrated in a single week; there are daily homework assignments and what we call an end-of-course assignment. A second approach is to pair two courses—one mathematics and one education—over a two-week period, each meeting for 40 hours during the two weeks. Our experience is that teachers appreciate our summer format because it allows for focused collaboration with colleagues while leaving most of the summer for other pursuits and minimizing time away from home. Additionally, as the NMSSI have expanded, we have of-

ferred more courses at more locations outside of Lincoln. This further minimizes housing and subsistence costs and time away from home for teachers who often must travel to a course's location to pursue graduate education.

In our grant-funded academic year courses, to support rural teachers we have used a blended distance-education approach, in which teachers meet face to face on one or two Saturdays during the semester and complete the rest of the course online. To further reduce costs when grant funds are not available, we are now offering online courses without a face-to-face component. Since teachers are quite busy teaching (and coaching and sponsoring other extracurricular events) during the year, online courses are often the best fit for their schedules and are the only option for teachers who do not teach within reasonable commuting distance of our colleges and universities. When we offer online courses we utilize a wide variety of available technologies in order to build professional communities and to support teachers' learning, from video conferencing (using Adobe Connect, Google hangout, or Skype) that enables group discussions to mathematical software such as GeoGebra and other online applets and virtual manipulatives to support mathematical exploration and representation.

In all of our courses we strive to maintain high expectations but also to provide teachers with as much support as they need to be successful. Courses, especially those with larger enrollments, are typically taught by teams of instructors, which often include university faculty, master teachers, and graduate students. Involving teachers on our instructional teams helps connect university faculty to the needs of teacher participants and provides a special form of professional development for the state's very best teachers. As we expand the NMSSI and other course offerings, more master teachers are becoming lead instructors for NMSSI courses. By investing in the capacity of Nebraska teachers to lead high-quality professional development courses for their peers across Nebraska, we are helping grow a community of outstanding academic leaders among Nebraska's K-12 mathematics teachers.

IMPACT ON TEACHER KNOWLEDGE AND BELIEFS

Teachers with deep mathematical knowledge for teaching are better prepared to educate students in ways that teach them to think mathematically. But teachers also need to be part of a professional community to thrive. Teachers in larger districts often have the benefit of peers in their building who teach the same course and with whom they

can plan common lessons. Rural teachers may not have similar peers teaching the same courses in their buildings, but they can develop connections with such peers in other schools and districts. When outstanding teachers are linked to each other and to university faculty they become part of a professional community, even if they teach in a rural school with few other mathematics teachers. By supporting each other rural teachers can raise the quality of mathematics teaching and learning statewide. Technology today is such that teachers can utilize videoconferencing and document-sharing technologies to plan together online, and to have rich discussions about teaching and learning mathematics. By developing a statewide community of mathematics teachers, we seek to help teachers connect with peers.

Teacher mathematical knowledge for teaching does increase as a result of participation in our programs. With our grant-funded programs, we have had K-8 teachers take an elementary or middle-level version of an assessment of mathematical knowledge for teaching. In general, score increases of greater than one-quarter of a standard deviation are considered significant growth. In Math in the Middle teachers' scores grew an average of half a standard deviation and these changes were maintained over time (Fig. 2). Because the test teachers took changed between the second and third cohorts, cohorts 1 and 2 are reported together, as are cohorts 3-5. Thus, for Math in the Middle we have strong evidence of the positive effects of the program on participants' mathematical knowledge for teaching. In Math in the Middle we also administered an attitude survey to teachers, but because their attitudes were very positive as they began the program it was not possible to detect any changes over time.

We have similar strong results for K-3 teachers who participate in the Primarily Math program. When teachers enter the program their scores are comparable to those of K-3 teachers nationwide, but when they leave the program their scores are significantly higher (see Fig. 3). Note that the national sample is for K-6 teachers, but the Mathematical Knowledge for Teaching (MKT) creators report that K-3 teachers have lower scores than teachers of grades 4-6. Because our program is for K-3 teachers we expected the mean score for our teachers to be below the K-6 national average prior to beginning Primarily Math coursework. Afterward, however, their mean score is above the national average, representing a gain of more than half of a standard deviation. Indeed, while only 16% of all K-6 teachers nationwide score one standard deviation above the mean, 23% of the K-3 teachers who have completed Primarily Math score in that range.

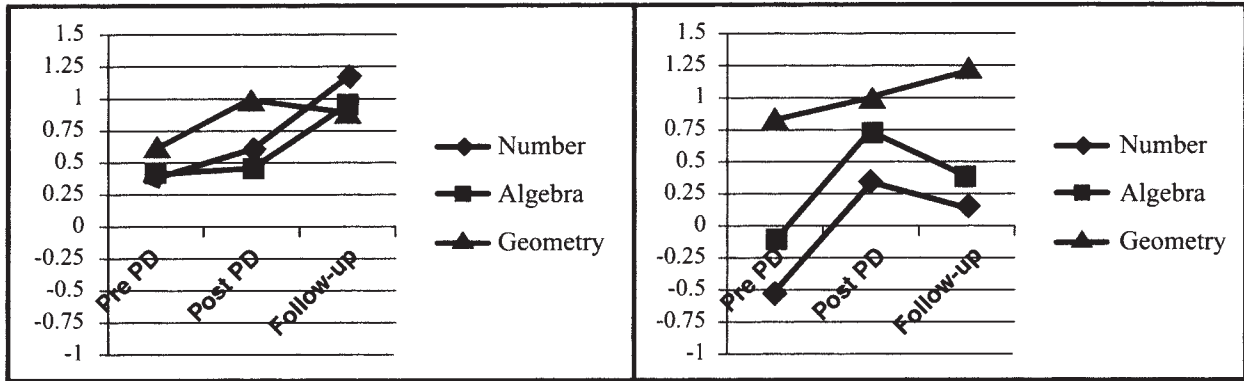


Figure 2. Math in the Middle cohorts 1 and 2 (left) and 3-5 (right) participants' mathematical knowledge for teaching by subscale (number and operations; patterns, functions and algebra; geometry).

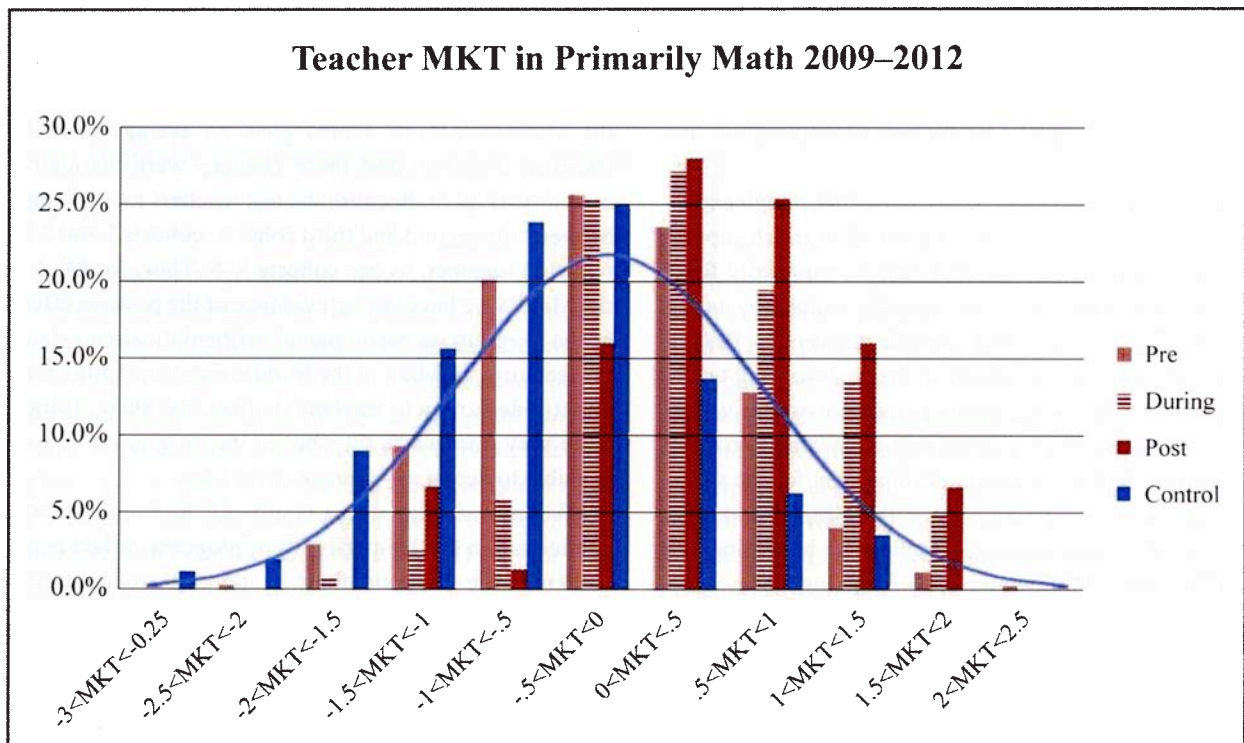


Figure 3. Distribution of Primarily Math cohorts 1-3 and control group teachers' mathematical knowledge for teaching, 2009-12.

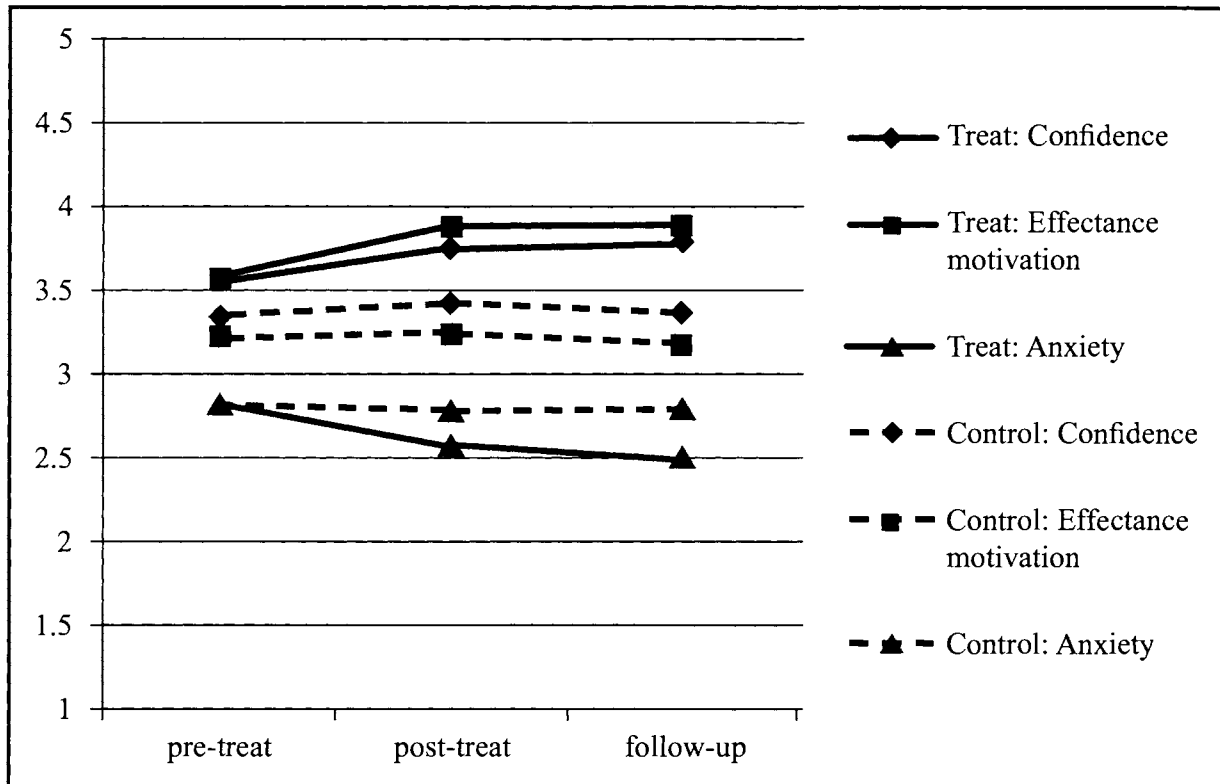


Figure 4. Primarily Math and control group teachers' attitudes toward mathematics, 2009-12.

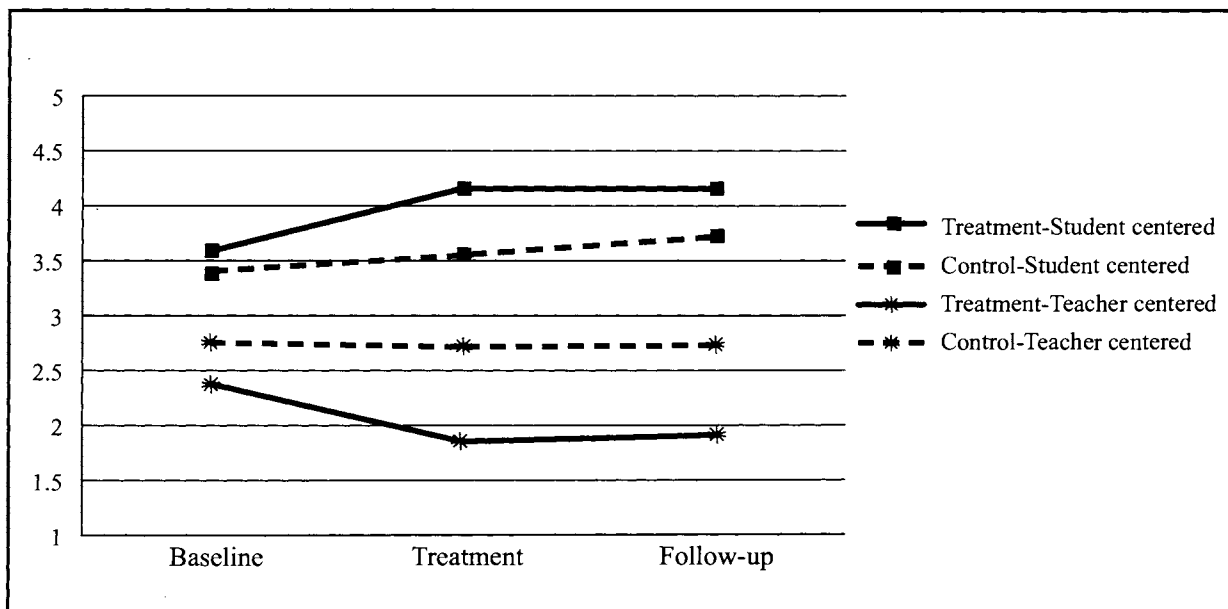


Figure 5. Primarily Math and control group teachers' beliefs about teaching mathematics, 2009-12.

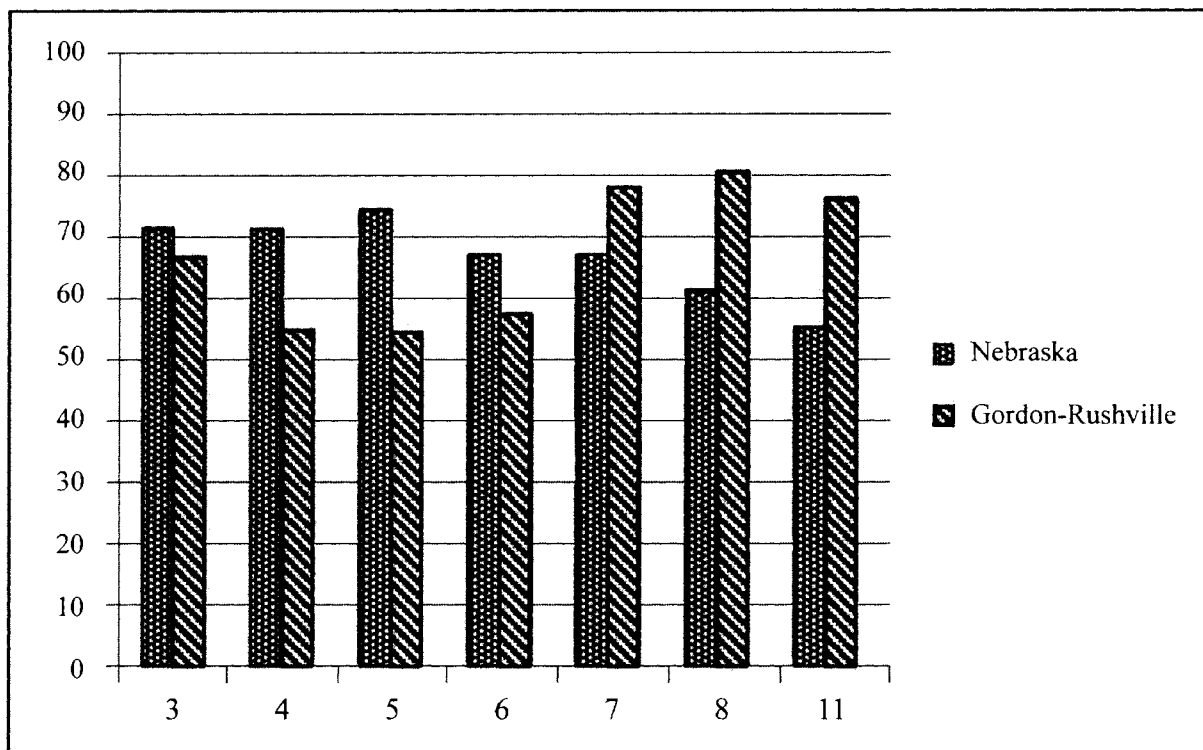


Figure 6. Nebraska and Gordon-Rushville percentage of students proficient on the state test for mathematics by grade level (3-8, 11), spring 2012. Source: Nebraska Department of Public Education 2012.

For Primarily Math we used a different instrument to measure attitudes and did see both increases in confidence and motivation and decreases in anxiety, whereas the control group teachers' attitudes remained statistically the same across time (see Fig. 4).

We also measured K-3 teachers' tendencies toward child-centered versus teacher-centered instruction, and found statistically significant differences between Primarily Math teachers—whose beliefs became more child centered and less teacher centered—and control group teachers, whose beliefs remained static (Fig. 5).

IMPACT OF PROFESSIONAL DEVELOPMENT ON STUDENT LEARNING

Our ultimate goal in improving teacher knowledge and changing teacher beliefs is to see an improvement in student learning. Given the history of assessment in Nebraska, using available data and existing statistical methods, it usually is not possible to analyze student scores to detect an impact of teacher professional development on student scores. Under the original state assessment system—School-based, Teacher-led Assessment and Report-

ing System (STARS)—every district created its own test, so one cannot make direct comparisons across districts. With the advent of the Nebraska System of Accountability (NeSA), it is possible to compare scores at a school or district level, but these data exist only for 2011 and 2012, and are not collected in a way that links students to teachers. Thus, with available statewide data it is not possible to determine if students with teachers who have gone through our programs are achieving at higher levels than others.

However, in rare instances in small rural schools with small numbers of mathematics teachers, we can look locally for evidence of the impact of professional development. Although these situations may not generalize broadly, they do illustrate specific instances of the impact of exceptional teachers on student achievement. For instance, Gordon-Rushville Public Schools, a consolidated district in northwestern Nebraska, has one middle school and two high school mathematics teachers. The middle school teacher and one of the two high school teachers participated in Math in the Middle, but none of the elementary teachers have participated in any of our professional development programs. All of the 7th graders had the middle school teacher, and over 80% of the 8th graders

TABLE 1
2012 Nebraska and Gordon-Rushville NeSA-M Percentage Proficient and Differences by Grade Level

	3	4	5	6	7	8	11
Nebraska	71.9	71.8	74.9	67.6	67.6	61.7	55.6
Gordon-Rushville	67.2	55.2	54.8	57.7	78.6	81.1	76.7
Difference	-4.7	16.6	-20.1	-9.9	+11.0	+19.4	+21.1

Source: Data from the 2011–12 State Report Card, the most recent year data are available. <http://reportcard.education.ne.gov/>

had the middle school teacher for both 7th and 8th grades; nearly 60% of the 11th graders had these two teachers for at least four years of mathematics instruction.

Gordon-Rushville Public Schools has 737 students, 54% of whom receive free or reduced-price lunches, and approximately one-quarter of whom are Native Americans. As a comparison, 43% of Nebraska students receive free or reduced-price lunches, and less than 1.5% of students are Native American. The statewide trend for NeSA-M scores steadily declines as students get older (see Fig. 6). Passing rates for Native American students are much lower than state averages and lower than scores for white students. Yet in Gordon-Rushville, at grades 7, 8, and 11 the NeSA-M scores are markedly higher than statewide scores (see Fig. 6 and Table 1). Additionally, across all grades tested, statewide data show only 36% of Native American students pass the NeSA-M, whereas 45% pass in Gordon-Rushville. Thus, Gordon-Rushville, as an outlier from state averages, points to the effectiveness of its middle and high school mathematics teachers, two out of three of whom have received substantial professional development to strengthen their mathematical knowledge for teaching. We note that these two teachers fit the typical rural teacher demographic in that one grew up in the community, and the other grew up in Wyoming but married a community member. We have begun to notice similar trends in the performances of students in other small districts with teachers with whom we have worked, but space constraints preclude us from telling all of these stories.

We considered whether Gordon-Rushville is an outlier compared to comparable rural districts across the state. Thus, we searched for public school districts of roughly the same size (secondary population within 100 students of the secondary population in Gordon-Rushville Public Schools) that were also in rural parts of the state (thus excluding districts in the Omaha and Lincoln metropolitan areas). This left us with 12 comparable districts, of which only 2 (Falls City and Fairbury) employ teachers with whom we

TABLE 2
Leigh Elementary and Nebraska NeSA-M Scores and Percentage of Students Proficient, Grades 3–5, 2012

	NE avg	NE% proficient	Leigh avg	Leigh % proficient
3rd grade	108	72%	150	100%
4th grade	106	71%	118	78%
5th grade	108	75%	134	*
6th grade	108	68%	136	91%

* Data masked due to fewer than 10 students (per Nebraska Department of Education policy)

have worked. Among those districts, Gordon-Rushville still clearly stands out as an exception (see Fig. 7).

We also examined Leigh Community Schools, a district where one Primarily Math teacher teaches third grade, and a Math in the Middle graduate teaches mathematics to the fourth, fifth, and sixth grades. Leigh Elementary’s third through fifth graders ranked third in the state of Nebraska in spring 2012 for the highest NeSA-M scores. All students who attended Leigh for the full school year, 2011–12, scored at the proficient level or above on the NeSA-M in spring 2012 (see Table 2). Thus, in Leigh, there seems to be a large positive impact on student mathematics achievement when students are taught for more than one year by teachers who have completed Math in the Middle or Primarily Math.

For both Math in the Middle and Primarily Math, we also collected student data. Since Math in the Middle occurred during Nebraska’s STARS era, we knew that we would not be able to use district test scores as a comparative indicator of student achievement. Thus, we created an alternative assessment that emphasized writing to explain mathematics for use with fifth through ninth grade students and administered it in classrooms of Math in the Middle teachers. The overall picture of student data showed that students struggled to express mathematical reasoning in writing. However, our assessment did not have sufficient reliability to make strong claims, as we were unable to equate the fall and spring forms of assessment satisfactorily.

In Primarily Math we administered the Test of Early Mathematics Ability, 3rd edition (TEMA-3) to a subset of students in a subset of Primarily Math classrooms (2009–13), as well as selected classrooms in schools with a mathematics coach (2010–13) and control group classrooms (2009–13). The TEMA-3 Math Ability Scores are based both on a student’s raw score and age at the time of testing, and scaled to have a mean of 100 and standard deviation of 15, based on a nationally representative normative group of children ages two through nine. Thus,

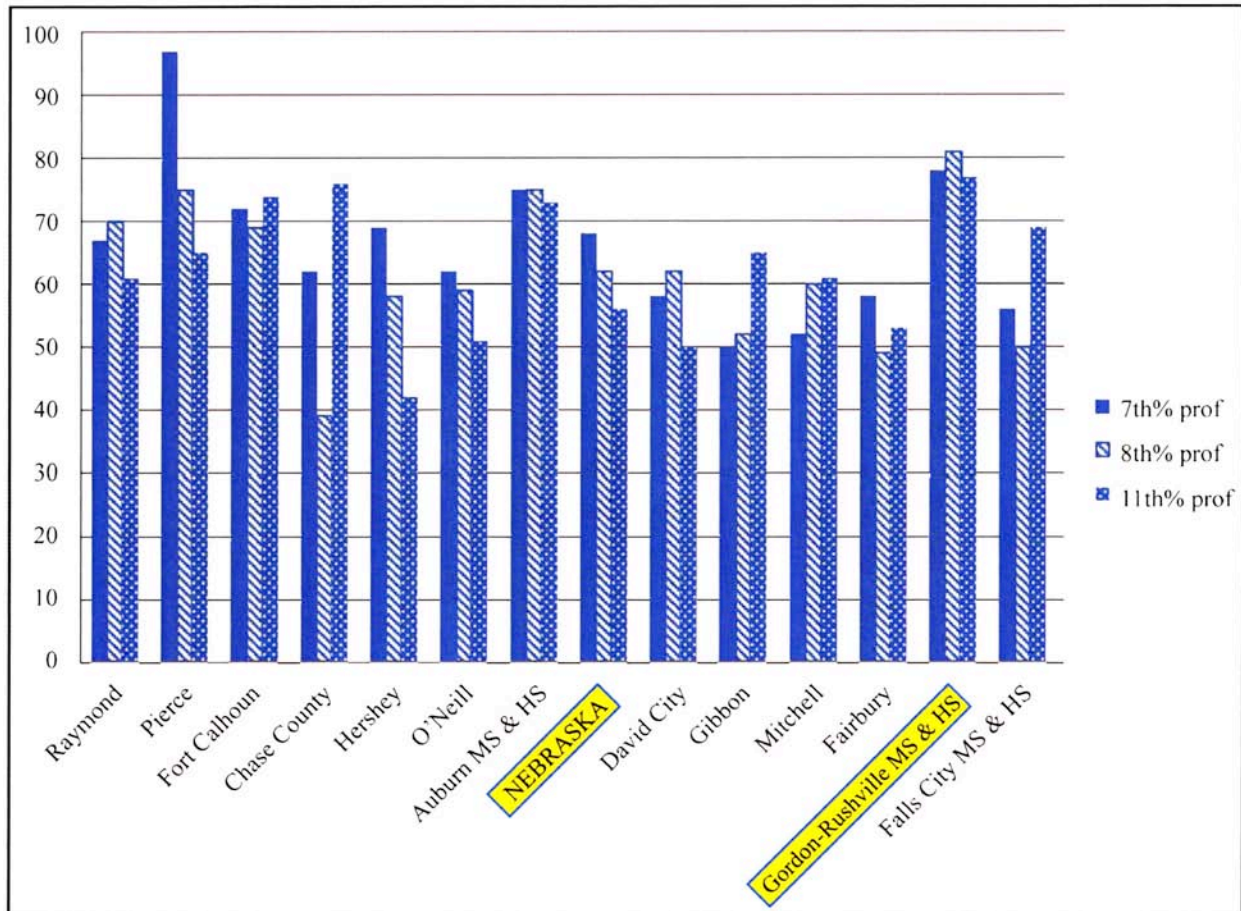


Figure 7. Percentage of secondary students scoring "Proficient" on NeSA-M 2011/12; schools are ordered left to right from lowest to highest percentage of students receiving free or reduced-price lunches (16%–56%). Source: Nebraska Department of Public Education 2012.

a child of average ability making average progress each year would have a Math Ability Score of 100 each time he or she were tested. Although we have tested over 5,000 students across a four-year span, we recognize that student scores are not independent of classroom (teacher) effects. When we look at teachers' class scores across time, we see positive trends, but power analyses reveal that we would need to obtain similar results in a much larger number of classrooms to conclude that the data indicate statistically significant differences among groups. With the advent of the NeSA-M in 2010–11, teaching and learning mathematics became more a focus of teacher professional development and teacher conversations than in the past. Nevertheless, we have started to see trends from fall to spring that show that control group classrooms average gains of 7.5 points, classrooms in buildings with a math coach average 9-point gains, and Primarily Math classrooms average 11.2-point gains. Thus, while all groups

have strong gains, Primarily Math classrooms have bigger gains (see Fig. 8).

CONCLUSIONS

Across our collective decades of work with mathematics teachers in Nebraska, particularly rural teachers, we have identified two recurring features that can support teachers' success in effectively teaching students mathematics: high-quality professional development and professional connections. Our findings specific to mathematics education support what Barley and Beesley (2007) found in their case studies of successful rural K–12 schools across subject areas in Wyoming, Missouri, and Colorado. They also support what Howley et al. (2007) found when interviewing 20 principals from three rural regions of Ohio about reforming high school mathematics teaching and learning. A university is arguably well positioned to pro-

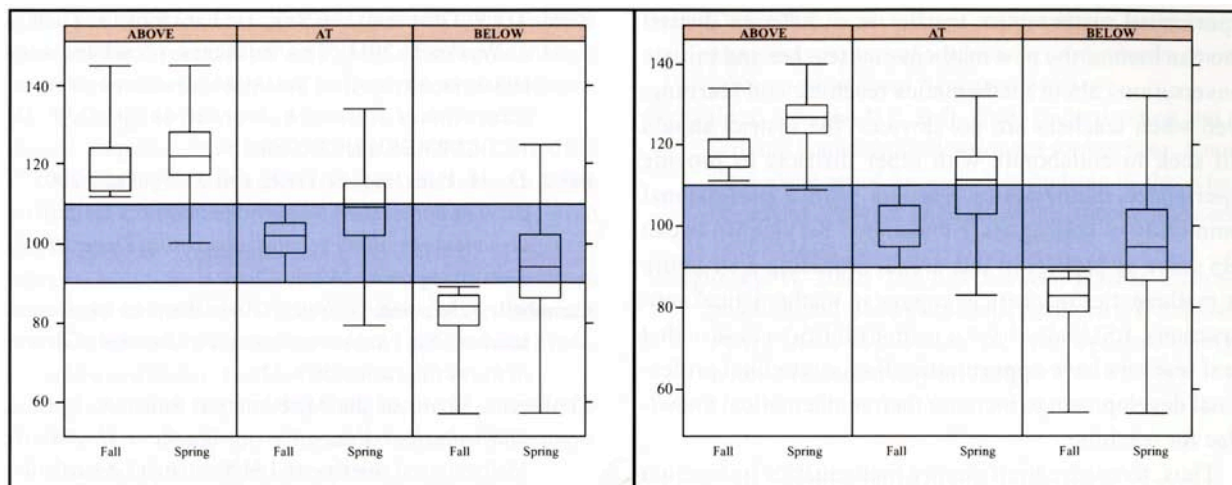
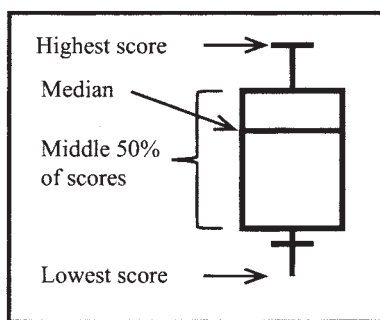


Figure 8. TEMA-3 Scores for 2011-12 for students comparison classes (left) and Primarily Math classes (right), split by fall scores (above, at, or below average). Note: These box-and-whisker plots should be interpreted as shown here. The plots above show the spread of student scores among those who scored above average, average, or below average in the fall. Thus, for instance, one can see that nearly 75% of students who scored below average in the fall and had a Primarily Math teacher went on to score average or above average in the spring.



vide high-quality professional development that deepens teachers’ mathematical knowledge for teaching if the institution makes it a priority to provide such opportunities. At UNL we have created and regularly offer dozens of courses designed to strengthen teachers’ mathematical knowledge for teaching (see <http://scimath.unl.edu/nmssi>) and using delivery systems that are especially sensitive to the needs of rural teachers. We have evidence that we are able to successfully improve K-12 teachers’ mathematical knowledge for teaching through such courses, and specifically through Primarily Math and Math in the Middle. Such knowledge is important, because without a deep knowledge of mathematics for teaching, teachers are unable to effectively teach students mathematics.

Professional connections also matter. In our grant-funded programs, we have deliberately built in structures to support the development of professional connections among mathematics teachers. Two electronic newsletters enable us to communicate with over 1,000 educators each month. For Primarily Math, we built in study groups to help make ways for rural teachers to connect around discussions focused on teaching and learning mathematics. Hellsten et al. (2011) say that rural teachers need help seeking out mentorship relationships and making

connections within and outside of the community. When such connections are made, rural teachers are much more likely to stay in rural areas. Such connections also provide a conduit for continued professional growth in the area of mathematical knowledge for teaching by providing stimulating discussions about mathematics teaching and learning. UNL has put great efforts into helping teachers get connected across the state. Our findings expand understanding of the importance of “community connections” in rural school settings (Barley and Beesley 2007) from community as the locale in which the school is situated to a professional community of math teaching peers engaged in communication about mathematics teaching and learning within a single school, between schools and districts, as well as across the state.

Rural school districts have a vital role to play in professional connections. School districts need to collaborate in order to effectively mentor new teachers as well as to develop and sustain collaborations among teachers to improve mathematics teaching and learning over time. Often, when a rural district hires a new mathematics teacher, there is not another mathematics teacher in the building to serve as a mentor for the new teacher. Thus, the district needs to have partners in order to find an

experienced mathematics teacher in a different district who can mentor the new mathematics teacher and initiate conversations about mathematics teaching and learning. Even when teachers are not novices, the district should still seek to collaborate with other districts to provide experienced mathematics teachers with a professional community of colleagues. Educational Service Units can help serve as brokers in this arena, providing a structure for mathematics teachers to engage in mathematical conversations. ESUs also have a responsibility to ensure that rural teachers have opportunities for longitudinal professional development to increase their mathematical knowledge for teaching.

Thus, to ensure high quality mathematics instruction in their schools, rural districts should invest in high-quality teacher professional development for their mathematics teachers and support their teachers as members of a larger mathematical community of educators. Such measures can be very effective in even the smallest districts, with no need to consolidate smaller districts into larger entities to pursue this strategy. We do believe these measures are more effective when districts and ESUs work in partnership with mathematics and mathematics education faculty at UNL. Certainly we all share the common goal of high achievement of Nebraska students; investing in rural teachers and supporting connections among teachers will help us achieve this goal.

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