ABSTRACT: One-third of all U.S. school children attend school in rural settings. Rural schools are much poorer than urban America, with most of the poorest counties in the United States located in rural areas. Equity is a concern not only in terms of race, class, gender, disability, and sexual orientation, but also in terms of being geographically located in a rural area. Rural teachers are often not certified in their teaching areas, with one in four rural science teachers lacking in academic preparation or certification. This article describes the K20 Oklahoma Science Initiative for Rural Schools that targets low-income, rural schools serving diverse populations in Oklahoma. The K20 Initiative helps reduce the professional, cultural, and social isolation and lack of professional development in rural schools. The objectives of the initiative are to improve teacher quality and student success through three research-based strategies which are described in the article.

Rural America, representing one-third of all U.S. schoolchildren, is much poorer than urban America, with 59 of the 66 poorest counties located in rural areas (Gates, 2004). Rural schools are at a disadvantage when competing for resources for professional development and attracting qualified teachers, with one in four rural science teachers lacking in academic preparation or certification (National Science Board [NSB], 2006). More than 400,000 educators teach in rural schools, representing 31 percent of all public school teachers (National Center for Education Statistics, 2002). Compared to their non-rural counterparts, rural teachers average 13.4 percent less in salary, live in sub-standard housing, experience professional, cultural, and social isolation, and receive little if any professional development (Beeson & Strange, 2003; Darling-Hammond, 2000; Education Trust, 2003; Jimerson, 2003). Thus, although social justice is often discussed in terms of race, class, gender, disability, and sexual orientation, it may also be an issue of location—in this case, being located in a rural area.

The purpose of this article is to call attention to a neglected dimension of social justice—social justice for rural schools and, particularly, for the education of the students who attend these schools and the professional development of the educators who serve in them. We do this by describing the kindergarten through graduate education (K20) Oklahoma Science Initiative for Rural Schools, a program within the K20 Center for Educational and Community Renewal at the University of Oklahoma. The Oklahoma Science Initiative for Rural Schools [K20 SCIENCE] targets low-income, rural schools serving diverse populations in Oklahoma (including the 22,000 Native Americans who attend rural Oklahoma schools). K20 SCIENCE is one initiative that helps reduce the professional, cultural, and social isolation and lack of professional development in rural schools. The initiative is focused on science education due to the dire need in that area. The National Science Board (2006) reports that “the critical lack of technically trained people in the United States can be traced directly to poor K-12 mathematics and science instruction” (p. 2).

Research on professional development finds that teacher learning is greater when professional development utilizes an embedded professional development approach, linked directly to student achievement (e.g., lesson study, authentic research experience for teachers, professional learning communities), rather than the traditional workshop or conference format (Garet, Porter, Desimone, & Birman, 2001). Similarly, Fullan (2001, 2003) notes that to significantly improve student learning, teachers must be learning. Based on this knowledge, the K20 Center at the University of Oklahoma and the Oklahoma Science Project (OSP) developed an embedded professional
development model. For 12 years, OSP has provided authentic research experiences for rural science teachers with 48 teachers (four per year) completing the program. The K20 Center for Educational Renewal and Community Development has, for ten years, promoted systemic ‘whole school’ reform through a school-university network designed to transform conventional schools into professional learning communities (PLCs) using peer coaching, regional networking, and the IDEALS systemic change framework (O’Hair, McLaughlin, & Reitzug, 2000). In recent years, over 500 rural schools have participated in this effort.

This article describes a professional development model that moves beyond a conceptual framework to one that is evidence-based and which combines strengths of OSP and K20 to promote exemplary science instructional practices in 7th -12th grade rural classrooms. The objectives are to improve teacher quality and student success through three research-based strategies:

1. **Authentic research experiences for teachers** to deepen understanding of scientific inquiry while enriching substance and process (Kincheloe, 1991; Newmann, 2000)

2. **Lesson study**, credited with Japan’s evolution in mathematics and science teaching (National Research Council [NRC], 2002), to translate learning that occurs during teachers’ research experiences directly into classroom practice.

3. **Professional learning community** (PLC), including peer coaching and regional networking, to support authentic intellectual work which has been associated with higher levels of student achievement (Lee & Smith, 1996) and which reduces the remoteness and isolation which affects rural teachers’ learning (Malhoit & Gottoni, 2003).

Merging these well-established approaches, the K20 SCIENCE Initiative for Rural Schools deepens teachers’ content knowledge while impacting large numbers of rural teachers and classrooms across the state.

**The K20 Science Initiative for Rural Schools**

The K20 Science Initiative for Rural Schools includes two main components: interactive instruction, and embedded professional development.

**Interactive Instruction**

The most prominent theories on how students develop understanding are based on the ideas that learning is active (Bransford, Vye, Bateman, & Brophy, 2004), involves the acquisition of organized knowledge structures and social interaction (Piaget, 1972; Vygotsky, 1978; Greeno, 1997), and relates new information to existing cognitive structures in order for learning to be meaningful (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991; Good & Brophy, 2000; Hannafin & Land, 1997; Jonassen, 1999). Additional research has documented substantial achievement benefits for all students, regardless of school level, size, context, ethnicity or socioeconomic status (SES), when students are exposed to the kinds of teaching characterized as interactive instruction producing authentic intellectual work (Smith, Lee, & Newmann, 2001). This type of teaching results in students producing intellectual artifacts that are worthwhile, significant, and meaningful, such as those undertaken by successful adults (i.e. scientists and other professionals) who apply basic skills and knowledge to complex problems (Newmann & Wehlage, 1995; Newmann, 1996). Educational researchers have developed instructional strategies based on experiential learning, meaningfulness, and reflection, in order to facilitate the development of knowledge that can be applied more flexibly to different contexts and problems (e.g., Blumenfeld et al., 1991; Bransford, Brown, & Cocking, 2000).

Authentic assignments using interactive instruction require students to (a) construct knowledge involving organizing, interpreting, evaluating, or synthesizing prior knowledge to solve new problems; (b) engage in disciplined inquiry (i.e. use of a prior knowledge base; striving for in-depth understanding rather than superficial awareness; and expressing one’s ideas and findings through elaborated communication); and (c) provide value beyond school for the learning. “These three criteria – construction of knowledge, through the use of disciplined inquiry, to produce discourse, products, or performances that have value beyond school – form the foundation for standards to assess the intellectual quality of teaching and learning” (Newmann, Bryk, & Nagaoka, 2001, p. 14). Recent research supports that interactive instruction producing more authentic intellectual work improves student scores on conventional tests (Newmann et al., 2001), student motivation to learn (Greene, Miller, Crowson, Duke, & Akey, 2004; Roeser, Midgley,
& Urdan, 1996), and is linked to student success in high school science and mathematics (Lee, Croninger, & Smith, 1997). The effectiveness of interactive methods is supported by substantiated theory on how students learn (Bransford et al., 2000; Good & Brophy, 2000; Hannafin & Land, 1997; Jonassen, 1999).

Concerns about the reluctance of teachers to implement interactive instruction are not new (e.g., Blumenfeld et al., 1991). For students to receive interactive instruction that engages them in authentic intellectual work, teachers must learn new teaching methods and acquire more subject matter knowledge as well. After studying 2017 assignments from 277 teachers, Newmann and colleagues (2001) concluded that asking teachers to effectively implement authentic intellectual work necessitates providing resources for integration and assessment and professional networking opportunities.

The K20 SCIENCE Model, described next, combines three strategies linked to accelerating and supporting change from didactic to interactive pedagogy: authentic research experiences for teachers, lesson study, and professional learning communities.

**Professional Development**

K20 SCIENCE is a program designed to foster interactive instruction for conceptual understanding in science classrooms by:

1. deepening the content knowledge and comfort with inquiry-based teaching of rural secondary science teachers through authentic research experiences;
2. transferring and sustaining teachers’ authentic research experiences into classroom practice through lesson study; and
3. creating professional learning communities that provide meaningful learning experiences for teachers and students.

The goals of K20 SCIENCE address specific needs through research-based strategies emphasizing interactive instruction.

**Goal 1: Deepening Content Knowledge and Comfort with Inquiry-Based Teaching of Rural Secondary Science Teachers Through Authentic Research Experiences**

**Need.**

Research connects increased student achievement in science with teaching for understanding of both science disciplinary content and the centrality of inquiry in science (Pasley, Weiss, Shimkus, & Smith, 2004). Developing high quality mathematics and science teaching requires deepening teachers’ content knowledge through sustained professional development (NSB, 2006). The National Science Education Standards identify more attention to inquiry as the hallmark of good science instruction (National Research Council, 2002). Teachers who have not experienced inquiry-based, interactive instruction are ill-equipped to employ this instructional strategy in their classrooms (Newmann, King, & Youngs, 2000).

**Research-based strategy: authentic research experiences for teachers.**

Authentic research experiences for teachers provide sustained opportunities for teachers to experience an instructional strategy while they study, experiment with, and receive helpful advice on scientific content; collaborate with professional peers both within and outside of their schools; have access to external experts (i.e., research scientists); and have influence on both the substance and the process of their professional development (Newmann et al., 2000). Experiences of the OSP program over the past 11 years found that teachers readily gained the essentials of scientific inquiry, including confidence in their ability to carry through a rationally conceived research project from beginning to end, when provided authentic research experiences and guidance (Silverman, 2003). In addition to confidence in research ability, teachers’ mastery of the scientific content increased significantly through the research experience (Slater & Cate, 2006). As an added bonus, mentor research scientists improved their teaching and communication skills through authentic pedagogy that encouraged critical reflection and knowledge
construction through social interaction (Tanner, Chatman, & Allen, 2003).

**Implementation.**

The K20 SCIENCE Summer Research Institute (SRI) engages teachers in scientific discovery with scientists from the University of Oklahoma and assists them in teaching for conceptual understanding. The SRI involves an in-depth, 5-week summer research experience for rural teachers, including:

1. An introduction to scientific research, research methods, and experimental materials.
2. The designing and conducting of original authentic research with guidance from scientists.
3. The translation of research experiences into classroom practices that focus on conceptual understanding.

Teachers utilize wireless-enabled laptop computers and scientific probes to gather, record, and analyze data. During and following the SRI, teachers work in lesson study teams (see below). Upon completing the SRI, teachers submit a summary presentation of their research, reflections on the SRI, and formal lesson plans generated by lesson study teams. The K20 SCIENCE network is available for teachers to seek assistance and advice from other teachers, K20 SCIENCE staff, and research scientists. In addition, teachers completing the SRI have the opportunity to return as mentors for subsequent SRIs in order to support new teacher participants and add to their own research experience.

**Goal 2: Transferring and Sustaining Teachers’ Authentic Research Experiences into Classroom Practice Through Lesson Study**

Need. For 8 years, researchers at the Wisconsin Center for Education Research (WCER) National Center for Improving Student Learning and Achievement in Mathematics and Science (NCISLA) have worked with teachers and schools to create and study classrooms in which compelling new visions of mathematics and science are the norm. NCISLA found that fundamental reforms in learning and teaching are most likely to be achieved through professional development grounded in teacher inquiry and student conceptual understanding. Huffman and Hipp (2003) similarly found that teachers transfer their learning to the classroom and ultimately to student learning when they network with each other using processes, such as lesson study, designed to create mutual respect and trustworthiness among staff members.

**Research-based strategy: lesson study.**

Lesson study originated in Japan and has been credited with Japan’s evolution of effective mathematics and science teaching (Lewis, 2002a, 2002b; Lewis & Tsuchida, 1997; NRC, 2002). Lesson study is an iterative process focusing on what teachers want students to learn rather than on what teachers plan to teach (Lewis, 2002a; Stigler & Hiebert, 1999; Yoshida, 1999). A group of teachers develops a lesson together, one group member teaches the lesson while the others observe student learning; the group reconvenes to debrief, analyze, and if needed revise the lesson to incorporate the observations; and the teaching process begins again with a new teacher. This process of inquiring about their own teaching permits teachers to examine and adapt their practice, resulting in authentic achievement for students (Stewart & Brendufer, 2005). Through creating a culture of inquiry and demanding rigorous work, lesson study provides the opportunity for lifelong learning by teachers and a model for the students (Chokshi & Fernandez, 2004).

**Implementation.**

Using the process of Lesson Study, the SRI staff guides and assists participants in integrating scientific research processes into classroom practices whose objective is teaching for conceptual understanding. Teachers collaborate (during and after their SRI experience) to craft and refine lessons that utilize the principles of inquiry they have practiced during their research experience. With support from the K20 SCIENCE staff, teachers work with their teams throughout the school year to reflect on, revise, and refine the lessons and instructional strategies from the SRI experience.

The purpose of lesson study is not simply the improvement of a single lesson. Rather lesson study provides teachers with an opportunity to examine their teaching in a way that results in the transfer of new knowledge acquired during the SRI research experience directly to their classrooms, ultimately resulting in the improvement of student
achievement (Lewis, Perry, & Hurd, 2004). Teachers completing the SRI experience also engage in lesson study to share their learning with colleagues in their schools. Lesson study teams of four to six teachers, either within a school or within a region, meet for a full day monthly, using release time or stipends, to cooperatively build and script a science lesson and carry out the lesson study process. K20 SCIENCE staff members or outside experts are available during these meetings in a consulting capacity. During the lesson study process, the teachers collaborate to consider core and cross curricular strategies, analyze student learning, and develop small communities of practice. A teacher subsequently teaches the lesson to his/her own class, while the other team members (and K20 SCIENCE staff) carefully observe how the students are learning the concepts and skills. Following the lesson, observers report to the teacher and the team revises the lesson consistent with the feedback. Subsequently the revised lesson is re-taught by a different teacher. The debriefing and revision process continues until the teachers are satisfied with the lesson and feel that it exemplifies inquiry learning standards and maximizes student conceptual understanding.

Goal 3: Creating Professional Learning Communities (PLCs) that Provide Meaningful Experiences for Learners

Need.

An early OSP evaluation indicated the lack of sustaining variables such as teacher networking throughout the school year to deepen learning and accelerate the change process in science classroom practices (McCarty, 2003). In that program, teachers generated curriculum documents at the conclusion of their research experience that were posted on the OSP website. Subsequent interviews with OSP teachers revealed that these documents were rarely used after the initial SRI experience (Slater & Cate, 2006). Teachers indicated that although the curriculum documents were important, isolation and lack of peer interaction and support reduced their use of the documents.

Research-based strategy: Professional Learning Communities (PLCs).

Researchers (Atkinson, 2005; Williams, 2006) have found that Professional Learning Communities and Technology Integration (TI) provide supportive conditions that foster peer interactions and changes in classroom practices leading to interactive teaching that enhances authentic intellectual work of students. Early constructivist research (Dewey, 1938; James, 1958) supports the work of recent theorists (Dufour, Eaker, & Dufour, 2002; Hord, 1997; Senge, 2000), who report that PLCs, an approach to engaging school staffs in meaningful learning, leads to increased student achievement (Huffman & Hipp, 2003; Lee & Smith, 1996). Research reveals that a strong sense of community not only increases persistence, but also enhances information flow, learning support, group commitment, collaboration, and learning satisfaction (Rovai, 2002; Wellman, 1999). How successfully a science innovation travels across diverse conditions and geographical areas depends on the extent to which a teachers’ academic support network is established (Carpenter, 2004). Technology helps expand teachers’ access to a larger community of learners, and as noted by the National Staff Development Council (NSDC) (2001), allows teachers to exchange ideas with each other and leading experts in their content areas, visit classrooms of exemplary teachers, receive coaching from their mentors via internet conferencing, and access online virtual libraries (Loucks-Houseley, Love, Stiles, Mundry, & Hewson, 2003). Schools functioning as PLCs promote collective responsibility for student learning and develop norms of collegiality among teachers and have been associated with higher levels of student achievement (Lee & Smith, 1996; Little, 1993; Louis, Marks, & Kruse, 1996). Not only is students’ achievement significantly higher in schools that function as professional learning communities, but those gains also are also distributed more equitably. That is, the achievement gap between students of lower SES and students of higher SES is narrower (Lee & Smith, 1994). Developing PLCs and networks among rural educators decreases the remoteness and isolation that often plagues rural teachers (Malhoit & Gottoni, 2003).

Implementation.

A professional learning community can be as small as an individual classroom or as broad as a network of schools across a state. Within a classroom, the PLC is focused on effectively implementing K20 SCIENCE instructional strategies to increase student achievement in science and includes interactive instruction and authentic intellectual work standards (Newmann, 1996; Smith et al., 2001). Classroom practice considers students’ prior knowledge and encourages construction of new knowledge based on experiments, demonstrations, extensive written and oral communication, problem-solving, and real world connections. Authentic, high-quality science lessons provide
opportunities for students to interact purposefully with science content and focus on the overall learning goals of the concept.

At the school level, the PLC strategy expands learning of teachers to include the entire school community, creating a collaborative, sustaining culture to improve the school’s capacity to help all students learn at high levels (Dufour et al., 2002). K20 SCIENCE teachers equipped with internet based video-conferencing capabilities are encouraged to network and collaborate on classroom projects with other rural teachers and scientists. Video-conferencing collaborations have received exceptionally positive feedback from students and teachers.

Additional opportunities for networking include the K20 network of 500 rural school leaders and their school boards. K20 SCIENCE strategies are introduced, studied, and discussed in initial 2-day leadership seminars for administrators wishing to join the K20 schools network; professional meetings with partner organizations such as the state’s school boards association, administrator and teacher associations, and K20 regional cluster meetings designed for ongoing professional development.

Conclusions and Implications

Low-income, rural students and their teachers are the forgotten underrepresented group. Students living in rural areas of the U.S. achieve at lower levels and drop out of high school at higher rates than their non-rural counterparts (Roscigno & Crowley, 2001). Additionally, in Oklahoma, the state in which the K20 SCIENCE Model is based, the poverty rate is 14.7 percent (compared to the national average of 12.5 percent), but for Oklahomans living in rural communities, the poverty rate is 18.3 percent (Oklahoma Institute for Child Advocacy and Arkansas Advocates for Children and Families, 2004; U.S. Census Bureau, 2004). Nearly 25% of Oklahoma students drop out of high school between 9th and 12th grade and too many Oklahoma high school students fail to learn higher levels of science that lead to college graduation and scientific and technical careers. Particularly disadvantaged are Native Americans. According to the National Assessment of Educational Performance (NAEP) assessments from 1996 through 2003, Native American students nationally are scoring below other students at 4th, 8th, and 12th grade levels. In addition, approximately 22% fewer Native American students complete the core coursework in high school.

Teachers in rural areas are often not prepared or certified in the subjects they are teaching. This is particularly true in science education where 24% of rural science teachers lacked academic majors or certification compared to 18% of teachers in non-rural settings (Indicators, 2006). The K20 Center network of 500 rural schools provides an extensive infrastructure from which to design, implement, test, revise, and share results of rural education innovation. The K20 SCIENCE Initiative for Rural Schools described in this article directly impacts these low-income, rural schools. Although early in its implementation, participating rural teachers report strengthening their own scientific understanding and how students develop scientific understanding; making complex changes in pedagogy to foster that development; and reinventing their practice in such a way as to reflect authentic intellectual work both in themselves and their students.

While the K20 SCIENCE Initiative directly impacts rural schools in the state of Oklahoma, the Initiative has broad implications for schools nationally and perhaps internationally. CNN Polling Director Keating Holland examined U.S. Census data and identified 12 key statistics—four that measure race and ethnicity, four that examine income and education, and four that describe the typical neighbourhood in each state—and calculated how distant each was from the figures for the average state on each measure. Oklahoma ranked 6th nationally in the CNN poll of the most representative state in the country—the state that is a microcosm of the entire country (Preston, 2006). If Oklahoma is representative of the United States, the K20 SCIENCE Initiative has broader impacts than Oklahoma rural schools.

While equity in the United States is lacking for rural schools, other countries may or may not provide greater resources and support to their rural schools. Additionally, in some countries, the geographical setting at which inequity occurs may be different—for example, in some countries suburban and urban settings may be short-changed. The implication for governmental and educational leaders across the globe is that it is important to examine social justice and equity across geographical settings.

Although not every student will become a working scientist, all students, including rural students, need to make
informed decisions as citizens about crucial science issues involving health, environment, energy, spending, and ethics (Conn, 2004). K20 SCIENCE advances social justice in rural schools through new conceptions of teacher professional development that enhances learning and prepares citizens for democratic participation.

Endnote

1The K20 Center’s programs, including K20 SCIENCE Initiative, are committed to the promotion of the democratic education IDEALS – Inquiry, Discourse, Equity, Authenticity, Leadership, and Service, and are grounded in the knowledge bases on school and community partnerships, teacher quality, and student success.

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Notes

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