1.1 WHY SCIENTISTS MUST MOVE BEYOND K-12 CLASSROOM VISITS TO ACTIVE PARTICIPANTS IN PROFESSIONAL DEVELOPMENT COURSES FOR TEACHERS

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ABSTRACT

When was the last time you visited a K-12 classroom? For most scientists, the answer is within the last year. The reason – your child drags you out for show-and-tell during the annual career fair day or oral report on, "My mom is a meteorologist." While these isolated events help to provide students the opportunity to ask about different careers, these rarely impact student learning.

Educational research shows the most influential factor on student learning is teacher quality. Why is this important to scientists in general and meteorologists in particular? Only 4 out of 10 earth science classes are taught by teachers with six or more college courses in the field. For meteorology, less than one third of secondary earth science teachers took even a single meteorology course. When surveyed, only one third of secondary teachers felt "well qualified" to teach weather and climate (Weiss 2002). This lack of content knowledge reveals the need for scientists to provide teachers opportunities to learn about meteorology.

1. INTRODUCTION

Scientists at the Oklahoma Climatological Survey (OCS) have been involved with K-12 professional development through the EarthStorm program since 1992. This paper will show how the structure of the annual EarthStorm Weather Institute and the involvement of scientists as instructors successfully tackle the need for professional development opportunities that address teacher quality and content knowledge. After the 2005 workshop, participant comments seem to agree with the research in the need for more scientist-teacher partnerships.

In order to understand the importance of scientist-teacher partnerships, scientists must be aware of the issues teachers face everyday. New federal laws like No Child Left Behind and reforms in education are currently causing growing pains throughout the entire educational system. The effect of the new policies is like making a 360° turn in a cruise ship. It does not happen instantaneously. Brief descriptions of the major challenges facing our educational system are included to provide a context for the theme of this paper.

Finally, the paper will end with recommendations on how to build scientist-teachers partnerships. In the summer of 2005, OCS will move into the National Weather Center with other weather units from the Norman-area. The move will create new opportunities for OCS to collaborate with a large number of scientists resulting in potentially new K-12 professional development programs.

2. REFORMING OUR EDUCATIONAL SYSTEM

The American educational system is a complicated machine. Unfortunately, the moving parts are not all moving in the same direction. With each new decade there seems to be a new educational reform movement. For the past twenty years, the reforms have focused on standards, assessment, teacher quality, and student achievement. Regrettably, no one agrees on a systematic implementation of any one reform. The following sections describe how these reforms are helping or hindering the process of improving the educational system.

2.1. No Child Left Behind

During the past four decades the federal government has become increasingly involved in regulating public education. President Lyndon B. Johnson waged the "War on Poverty" with the Elementary and Secondary Education Act of 1965. Federal funds were allocated until 1975 to improve education for the lower class. By 1980, the pendulum had swung the other way. Ronald Reagan opposed federal meddling in education. After the first National Education Summit, George H. W. Bush issued "America 2000", a set of six goals to support the education standards movement. Goal 4 stated that U.S.

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students would be **first in the world in science and mathematics achievement** by 2000. This goal has yet to be reached. In fact, research shows U.S. students continue to improve at a slower rate than other nations (NCEP 2003 and NCEP 2000).

On January 8, 2002, President George W. Bush signed the No Child Left Behind Act (NCLB) of 2001 into law. The law addressed increased accountability for States, school districts, and schools; greater choice for parents and students, particularly those attending low-performing schools; more flexibility for States and local school districts in the use of Federal education dollars; and a stronger emphasis on reading. The full text of NCLB can be accessed at: http://www.ed.gov/policy/elsec/leg/esea02/index.html.

2.2. National Education Standards

As report after report emerged revealing that American students performed poorly compared to international students, a national cry arose for higher standards and accountability. These reports like "A Nation at Risk" and "Science for All Americans" highlighted the gaps between the skills of high school graduates and the skills required by a growing technical workforce. Given that the educational system created to produce an industrial workforce in the 20th Century cannot meet the needs of the technology driven 21st Century, systematic changes nationwide are required.

Politicians tackled the problem by legislating how receipt of federal funding depended on a district's or school's ability to meet accountability requirements. They expected proof that schools were producing graduates with the same skill-set across the country. With each piece of legislation, pressure mounted to create a common set of standards to be used by all teachers.

At the time, no documents existed containing this common set of standards to be used by all teachers. Realizing schools were in danger of losing federal dollars, a grassroots effort began to develop subject-specific standards. Top educators in each field formed committees to formulate, debate, and write these standards. *Education Week* describes three general categories of standards being developed:

- **Academic standards** describe what students should know and be able to do in the core academic subjects at each grade level.
- **Content standards** describe basic agreement about the body of education knowledge that all students should know.
- **Performance standards** describe what level of performance is good enough for students to be described as advanced, proficient, below basic, or by some other performance level.

In 1996, a committee formed by the National Research Council published the National Science Standards containing standards in the following areas: science teaching, professional development of science teachers, assessment in science education, science content, science education programs, and science education systems. Science teachers across the country are working to incorporate these standards into their teaching.

Historically, local officials had full authority to governed American schools. These local officials made the final decision on what would be taught in their schools. However, the local tax dollars have not been enough to operate the schools. Over the years, school districts have become even more dependent on the state and federal governments to supply additional funds. In order to qualify for these additional funds, local officials have to meet requirements set by both the federal and state legislatures. These requirements are laid out in bills like NCLB and in the state standards used to test student achievement.

2.3. Teacher Quality

Under NCLB, schools must provide highly qualified teachers at all grade levels and in all core academic subjects. The requirements to be highly qualified include a bachelor's degree, full certification from the state, and show competency in each core academic subject taught (U.S. DOE, 2004). All schools must have highly qualified teachers in place by the beginning of the 2005-2006 school year. (In October 2005, Education Secretary Spellings extended the deadline.)

Notice there is no requirement that the bachelor's degree be the same as the subject taught. Each state has the power to establish the requirements for issuing teacher certifications and determining when the requirements have been met. Each state creates and administers the subject content examinations used to meet the third requirement. The states also set the minimum passing scores for these exams.

As states began to formalize their NCLB plans, many became concerned that they would not be able to meet the NCLB requirements by the deadline. Teachers with general science or biology bachelor degrees teaching physics or chemistry wondered if they would be forced to obtain additional bachelor degrees.

In response to these concerns, the U.S. Department of Education began issuing "fact sheets" which are available at http://www.ed.gov/. The fact sheets provide plain-English interpretations of NCLB Act. They

highlight the flexibility in NCLB. One such flexibility for highly qualified teachers is called HOUSSE, High Objective Uniform State Standard of Evaluation. Each state is required to establish a HOUSSE plan. HOUSSE is the method for current teachers to achieve highly qualified status without returning to college. HOUSSE is a point system used to give teachers credit for teaching experience, professional development, and subject knowledge.

2.4. Professional Development

Traditionally, professional development for teachers consisted of a single workshop. Teachers were provided with new information or materials and expected to find a way to use them in their classrooms. In many cases, the workshop instructors had no further contact with participants after the last day. While teachers evaluated the workshops as valuable or useful, there was no way to know if anything from the workshop made it into the classroom. More importantly there was no way to determine a causal effect between the teacher attending the workshop and an increase in student knowledge or ability.

Paralleling the standards movement, new methods for professional development are needed to bridge improvement in teacher quality with student achievement. Susan Loucks-Horsley, a leading authority on staff development, standards, and science education, advocates replacing workshops with opportunities for teachers to work with scientists in lab settings (Sparks 1997). Teachers need to learn science through inquiry just like the standards require them to teach their students. When teachers learn through lectures and labs in their university courses, they tend to teach the same way. Memorization of facts does not improve the quality of students produced. Students must be able to ask questions and know how to use research techniques to find possible solutions.

Moreover, teachers find it difficult to stay knowledgeable of new scientific discoveries or research methods. Getting teachers out of the instructor role and back in the learner/student role is critical for keeping pace with cutting-edge science. Learning is not always easy. Part of the learning process is finding out you can overcome obstacles. Teachers need to live the emotional struggles their students encounter when learning new material. This helps teachers better understand their students (Hoff 2003).

Additionally, teachers need time to translate their new science knowledge into materials that will work in the classroom at a particular grade level (Darling-Hammond 1997). Improving teaching methods requires time to reflect on what works and what does not. Participation in study groups, examination of student work, and team lesson planning provide opportunities to remove teachers from isolation. Instead of going off-site to attend professional development workshops, much of the professional development is moving on-site within an individual school or school district. It is not enough to change the knowledge and habits of a few teachers. The changes need to occur throughout the educational system. The systemic changes must occur before changes in teacher quality, professional development, or student achievement can take root.

3. OBSTACLES TO NO CHILD LEFT BEHIND

No Child Left Behind has been a headache for both state and local officials. No one can agree on the correct interpretation of the law. NCLB has specific requirements for teacher quality, accountability, and professional development, but the definition of these terms differ widely from state to state.

For instance, NCLB requires highly qualified teachers in every classroom. The law focuses on the educational background of the teacher (i.e., having a bachelor's degree). But when asked teachers reply that subject content knowledge is not enough. Knowing how to teach a subject to a specific age group and making modifications for disabilities and English language learners are also important factors for being highly qualified (SECTQ 2004).

Critics claim that instead of improving teacher quality to meet NCLB requirements, states are writing teaching standards to meet the abilities of their current teachers (The Teaching Commission 2004). The HOUSSE Plans, which define the status of veteran or alternatively certified teachers, have made it extremely easy for the majority of current teachers to obtain highly qualified status. Another problem is that the HOUSSE Plans are not uniform from state to state. A teacher that is highly qualified in Oklahoma may not be highly qualified in any of the neighboring states.

Funding is another critical issue. The federal government created NCLB which school districts must follow. But states feel they have not been provided sufficient funding to provide programs to address increasing teacher quality, providing research based professional development, and creating methods for reporting their progress towards meeting NCLB requirements.

4. STATUS OF TEACHER QUALITY

Several surveys and reports have been conducted to track teacher quality to see if any improvements are evident. Many of these surveys are grouped based on teaching assignments: elementary, middle or

secondary. The Horizon Research group published their findings on science teaching based on a national survey conducted in 2000 (Fulp 2002a, Fulp 2002b, and Weiss 2002). The following describes their results.

The science teacher workforce for both elementary and middle school is made up of primarily white females. One quarter of these teachers will retire with in 10 years. When asked both groups cite content knowledge as the area where they need the most help. They feel very knowledgeable in pedagogical skills like listening and asking questions, managing hands-on activities, and organizing cooperative learning groups. But don't feel they have enough content knowledge to adequately teach science.

Elementary teachers rarely attend professional development for science or science teaching. Much focus is placed on reading skills in the elementary grades. This leaves little time for anything beyond professional development for reading instruction. At the middle school level, teachers no longer teach all subjects. Unfortunately, science teachers do not spend any more time on science professional development than elementary teachers. The teachers see the lack of quality science professional development as the problem. One fourth of middle school science teachers have not participated in even one science professional development experience from 1990 to 2000 (Fulp 2000b).

NCLB was written to level access to high quality teachers between suburban schools and rural and inner city schools. The current system allows veteran teachers first refusal for teaching assignments. This results in the most qualified teachers leaving the schools with the lowest performing students. Some districts are implementing signing bonuses and other incentives to attract high quality teachers to rural and inner city schools. Unfortunately, there is not enough funding available to make this practice widely available across the nation (The Teaching Commission 2004).

Tenure and pay raise schedules are other obstacles to improving teacher quality. Teachers need to be in the classroom for several years before their true skills become apparent. By that time, tenure is activated making it impossible to remove ineffective teachers. If a teacher is released from one district, the teacher just moves to the next district. Schools are passing around the ineffective teachers. This does not improve teacher quality. It just transfers the problem (The Teaching Commission 2004).

Pay raises tend to be tied to the number of years taught, not to improvements in student achievement (Carey 2004). This practice results in high quality teachers being paid the same amount as ineffective or inexperienced teachers (Darling-Hammond 1997). This does nothing to boost moral. Those teachers who do well in the classroom are usually promoted into administration where the higher salaries are. The teacher uninterested in administration but frustrated with their salaries tend to leave the profession entirely. Teacher unions continue to block any movements to change policies for abolishing tenure for performance-based pay increases (Winnick 2003).

The current system encourages the high quality teachers to leave the classroom while keeping the less effective teachers in low-performing schools. Until teachers are paid based on their effect on student achievement, the problem of teacher quality will remain.

The problems begin even before teachers enter the classroom. Teachers are ill prepared by our undergraduate degree programs. Half of the physical science teachers do not have a major or minor in any physical sciences. Twenty percent of science teachers do not have a minor in science or science education (Ingersoll 1999). College students majoring in education tend to have lower SAT and ACT scores than students majoring in arts or sciences (NCES 2001). Holding a Master's degree does not show any significant increase in student achievement.

A study by Sanders and Rivers (1996) reported that children taught by an ineffective teacher for one year, were unable to reach the same academic level as other students. But children spending one year with a highly effective teacher experienced academic benefits two years later. Research studies like this show the importance of removing ineffective teachers and finding ways to better prepare teaches for real world classrooms.

5. OVERVIEW OF EARTHSTORM

K-12 teachers partnered with the Oklahoma Mesonet even before towers dotted the Oklahoma skyline. In 1992, a National Science Foundation grant provided funding for a K-12 outreach program called EARTHSTORM (McPherson and Crawford). Originally, teachers attended a four-week intensive workshop: a one-week computer training workshop and a three-week meteorology content workshop. The National Staff Development Council in "Results-Based Staff Development for the Middle Grades Consumer's Guide" recognized the program in 1995.

By 1998, school computer labs began popping up across the state from Federal grant programs. With teachers' increased computer skills, the summer workshops were shortened to four days. Long-time EARTHSTORM teachers return each summer to mentor new teachers. Additionally, EARTHSTORM moved from paper copies of lessons to a complete web

site. The 2005 version of the web site is located at http://earthstorm.ocs.ou.edu. Over 25,000 teachers and students have attended tours, presentations, or workshops provided by OCS staff.

The most successful component of EarthStorm has been the annual student science fair. The Oklahoma Mesonet/ARM Science Fair has several unique features. Projects have to include weather data. The judges interview students about their projects, score projects, and provide written comments. The comments consist of descriptions of what the students did well from display layout to original project ideas. Most importantly judges discuss how students can improve their projects. Two projects even qualified for the International Science Fair, and subsequently won scholarship money. The Oklahoma Mesonet/ARM Science Fair is extremely proud of the 1215 students who have participated and entered 885 projects in the fair between 1993 and 2005.

After attending the science fair with her third grade students a teacher from Chickasha said, "Thank you to you and all of the people involved with the Mesonet Science Fair on February 22! I applaud everyone's effort to make it a positive learning experience for all of the students involved. After the awards ceremony, some of my little fledglings were already talking about possible projects for next year. Several of the parents of my students told me that they appreciated the kind and gentle interaction of the judges with the students. I appreciate this on-going opportunity for my students to participate in the scientific process."

Over 25,000 teachers and students have attended tours, presentations, or workshops throughout the past 13 years. Members of the EarthStorm team conduct or organize facility tours of the NWS, NSSL, SPC and OCS. These same members give presentations to schools around the state.

6. SUMMER TEACHER INSTITUTE

The EarthStorm Summer Teacher Institute is a four-day workshop that provides an opportunity for teachers to investigate weather and how to better prepare students for designing and implementing science fair projects. The Institute is free for Oklahoma and Kansas teachers thanks to funding from the Atmospheric Radiation Measurement Project and the State of Oklahoma. The participants receive a variety of handout materials that can also be used in their classroom, and hands-on lab activities are incorporated into the workshop. Speakers from a variety of weather agencies provide content on a range of meteorology topics. The workshop is wrapped up with lesson brainstorming and feedback on what other topics teachers would like to learn.

During the workshop hands-on activities are conducted, such as Swirled World, which makes a model of our earth's atmosphere. Teachers pour milk onto a plate with the four cardinal directions marked on the edge; the milk represents the atmosphere surrounding the earth. Drops of food coloring are randomly placed in the milk. Red food coloring represents a forest fire, green represents volcanoes, yellow represents pollution from car exhaust, and blue represents oil spills in the ocean. It is noted that the drops do not spread out, but remain stationary. Next dishwashing liquid, which represents energy from the sun, is squirted into the milk. The pools of color begin to bubble. If left alone the colors move throughout the milk mixing to a murky gray color. An extension to the activity is for teachers to blow gently through a straw towards the surface of the milk. This shows how winds contribute to the movement of storms in the atmosphere. The experiment is low in cost, and is a great hands-on activity for teachers to take back to the classroom.

The first day of the workshop is spent learning basic meteorology. This is geared towards new teachers who have never attended the workshop. Activities are conducted to illustrate fronts, air masses, and weather patterns. The second day, returning teachers join the fun. Each year a new topic is presented; this year the topic was radar. In addition, the teachers are trained how to use the in-house weather software application, WeatherScope. The computer lab is open in the evening for those who wish to spend more time working with the software. The third day is a continuation on radar training. Teachers spend time in a lab activity learning how to interpret weather radar using WeatherScope. The afternoon provides variety with a visit to the local National Weather Service office and a weather balloon launch. The fourth day pulls everything together with a lesson brainstorming session.

The workshop is conducted in a manner similar to a middle school classroom. A talk is given on a topic, e.g., global weather patterns. This is followed by a hands-on activity that illustrates the lecture. Teachers are given opportunities to ask questions to help them clarify their understanding. An excellent example of this is How Radar Works, a new component that was added this year. OCS worked with the Electrical and Computer Engineering Department at the University of Oklahoma to create a content-lecture and activity on radar. A lecture was presented on how various radars work and how they are used in observing and predicting weather. This was followed by an activity using radar guns that showed how the direction of particle movement in relation to the radar beam determines what percentage of the particle speed can be detected by the radar. When teachers pointed the radar gun directly at a moving car along the direction of movement, the speed recorded was higher than if they pointed the radar gun

at an angle. This demonstration helped the teachers understand radar velocities better than any crude computer schematic.

The Institute ends with a discussion of potential topics for science fair projects, lessons to be used in the classroom, and features the teachers would like to see added to WeatherScope. Back in the classroom, teachers take their new knowledge and impart it to their students. Contact is maintained throughout the year using an online forum through the EarthStorm web site. On the forum teachers and students can post questions for mentors and other meteorologists. The forums are checked several times a day and mentors answer questions quickly. The interaction between students and scientists result in better formulated science fair projects. At the annual Oklahoma Mesonet/ARM Science Fair, students present their projects for review by the scientists. Each year the project quality matures; thus, all three groups benefit from the ongoing community interaction.

7. SUMMER 2005 FEEDBACK

The teachers had positive and constructive feedback after the 2005 EarthStorm Institute. Many of their comments aligned with key points previously discussed from the research. Their feedback focused on what portions of the workshop were most helpful, concerns and suggestions, topics they would like to learn more about, and changes they would like to see in future institutes.

The research calls for more opportunities for teachers to interact with scientists. The EarthStorm participants appreciated that the majority of the speakers had a Ph.D. Having the chance to learn meteorology from meteorologists was an unique experience. Several teachers remarked that the speakers showed enthusiasm for the content and took the time to answer questions. The teachers did not feel the content was too far above their abilities.

Along with speakers from various weather agencies, teachers visited the National Weather Service Forecast office, the Phased Array Radar and saw a weather balloon launch. Typically, workshops begin their agenda with facility tours and the content comes second. Due to scheduling issues with the other agencies it was not possible to follow this format. This became an unexpected bonus. Several of the teachers felt more knowledgeable and prepared to ask questions on the tours having been through much of the course content first.

When asking thirty people what weather topics they would like to learn about, you get thirty different responses. Teachers said they want to learn more about weather characteristics not covered in this workshop, such as tornadoes and hurricanes. Additional interests included wanting to know more about cloud formations, what they mean, and whether or not they are used to predict the weather.

The majority of the teachers were very pleased with the experience. One teacher requested that the workshop last for two weeks instead of four days. Originally, the EarthStorm Institute was four weeks while funded by NSF. Much of the research agrees that longer in-depth studies provide the most impact on teachers returning to the classroom. A one-day update workshop during the school year was also requested. Again this falls in line with the theories of continued contact and support is needed to see workshop materials filter back to the classroom. The most encouraging comments for staff include: “It was absolutely great – I want to come back next year!”

8. CALLING ALL SCIENTISTS

The teaching profession is in the middle of a revolution. The changes required and needed to improve student achievement are coming at an ever increasing pace. Teachers will not be able to make improvements without support. The support must come from all communities: research scientists, business leaders, school districts, universities, and state education departments.

How can scientists help improve education?

- Scientists need to move beyond one-time visits to schools for career day.
- Visit schools to see how they operate.
- Speak with teachers to understand the challenges they face.
- Ask students about what their science class is like: lecture vs. cook-book labs vs. inquiry labs.
- Read up on the laws regulating federal education funds.
- Understand how the national and state standards affect the content that is taught in the classroom.
- Track teacher pay, teacher turnover rates, and teacher shortages in low income, rural and inner city schools.

After scientists have a grasp of the difficulties facing teachers, long-term help can be provided. The university academic-specific and education departments can no longer exist in isolation (Ridky 2002). Learning biology from a biology department and teaching methods from the education department does not produce highly qualified teachers. The most profound learning occurs when students understand the interconnectedness of subjects. For years veteran teachers have seen success when using

interdisciplinary activities. However, teachers do not have the opportunity to see teaching methods used to teach science or math. When the science and education faculties begin to create joint courses, we will see teachers emerge from the university with the tools needed to be successful in the classroom. Teachers who learn science through inquiry activities instead of lectures will begin to teach by inquiry.

Once science teachers are in the classroom, they need opportunities to interact with scientists. This can be accomplished in many ways. Weekly seminars held at the local university are a wonderful venue to begin the teacher-scientist relationship. After the seminar, typically, the scientist opens the floor to questions from the audience. Go a step further. Give teachers the opportunity to discuss with scientists how their research can be brought into the classroom. Provide a list of articles students can read to supplement their textbooks. Discuss how data and experiments can be adapted for classroom use.

The National Science Foundation (NSF) has been increasing the requirements for an educational component to all funded grants. Many short-term K-12 programs are developed. But they only last until the funding ends. Why not add salary lines for a summer teacher positions? Use these teacher positions to help conduct the research. Instead of funding three graduate students, researchers could fund two graduate students and a teacher. The teacher could be required to participate in departmental seminars. The teacher would develop a lesson or two to be used in the classroom the following year. The researcher and/or graduate students could participate in delivery of the lessons.

9. CONCLUSIONS

As the National Weather Center (NWC) is populated over the next year, OCS will be cultivating relationships between scientists interested in working with teachers. The NWC will be more than just a building of scientists working for different agencies. It will be a haven for collaboration.

The EarthStorm Institute and annual science fair will continue. Additional speakers and judges will be drawn from NWC agencies. However, OCS wants to be involved in new ways. OCS has been brainstorming how the NWC can provide other services to improve teacher quality.

Universities have been very successful with REU (research experiences for undergraduate students) programs. These are aimed at helping students decide whether graduate school and in particular research is an avenue they want to purse. OCS will be looking for funding opportunities to support an RET (research experience for teachers) program (NRC 1996a). NSF currently funds RET programs. Once we have a solid base of scientists willing to spend summer research hours working with teachers, OCS will pursue NSF funding.

In order to build this group of scientists, OCS will begin with seminars on mentoring K-12 teachers. Eventually, these seminars may develop into a multi-day mentor workshop. Teachers will be asked to speak on how a scientist would best benefit their classroom. Some teachers may begin the process only looking for potential guest speakers. But the ultimate goal is to build long-term, mutually beneficial partnerships.

OCS will be looking for new opportunities to work directly with students. Many scouting troops are looking for ways to earn weather badges. Hosting weather courses similar to the Red Cross's CPR training will help to fill this void. From the phone calls received looking for summer weather camps, this is another area where NWC agencies could collaborate. The weather camps can run for a week from 9 am -12 pm or from 9 am – 3 pm. Because meteorology does not get the same attention as chemistry or physical science, scientists can spark interest in the field by spending a few hours during the summer talking with kids about the weather.

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