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**SPECIAL ISSUE ON SCIENTIFIC LITERACY**

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**Scientific Literacy in Central Appalachia  
Through Contextually Relevant Experiences:  
The “Reading the River” Project**

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Despite the best intentions of the United States educational system, implementing science reform efforts equitably and consistently throughout the nation is still a long-term goal. The light of scientific literacy has yet to shine brightly in many rural, isolated and economically depressed regions. Using Appalachia as a case in point, this paper provides a synopsis of the challenges of quality rural science education in the United States and the hope of new contextual and culturally relevant pedagogies aimed at engaging science students in inquiry research using their environmental surroundings as cognitive scaffoldings. The program *Reading the River* is showcased as an exemplary use of the students’ ‘backyard’ to integrate content knowledge in biology, chemistry, geology, physical science, social studies, practical living and mathematics.

**Key Words:** science literacy, scientific literacy, environmental education, rural education, contextual pedagogies, inquiry science

**Introduction**

In the United States of America, the quest for better science preparation is one of the basic pillars of school education. This preparation takes two inter-related forms, described by Roberts (2007) as developing knowledge about the processes and products of science (science literacy) and the social applications of science (scientific literacy). With the guidance of the National Science Education Standards (National Research Council, 1996) and the Benchmarks for Science Literacy (American Association for the Advancement of Science [AAAS], 1994), current and future K-12 science teachers should, in theory, be familiar with the importance of preparing students to have an appreciation for the values and principles of science, as well as a broad understanding of the body of knowledge associated with science, the processes of science and the scientific way of thinking. Moreover, the use of this information in daily decision-making about the natural world is emphasized in many school science curricula (Victor, Kellough, & Tai, 2008). However, in practice, implementing an effective inquiry-focused, reform-based science education program that increases the science literacy of all students re-

mains problematic. Some of the reasons include large class size, limited resources, lack of hands-on equipment, and teachers' limited experience in inquiry science and complacency with direct instruction. Similarly, teacher resistance to invest additional time and effort in planning and assessing has been reported (Duschl, 1990; Gallagher, 1989; Roehrig & Luft, 2004; Songer, Lee, & McDonald, 2003).

Many research studies have shown that the single most important school-based factor that contributes to student academic progress is the presence of a highly effective teacher in the classroom, that is, a teacher with mastery of both content and pedagogical knowledge (Appalachia Regional Advisory Committee, 2005). However, not all classrooms have access to effective science teachers, especially schools outside urban and suburban areas. Although rural and small town school districts represent about two thirds of all public school districts in the United States (Howley, 2001) and employ 40% of all public school teachers (Harmon, 2001a), they have difficulties attracting and retaining top quality teachers and implementing inquiry-based science curricula, which significantly impacts scientific literacy.

A few efforts to create and disseminate culturally relevant, place-based curricula that aim at a contextualized scientific literacy among rural students are in progress. The purpose of this paper is to provide a synopsis of the current issues that affect science literacy in rural areas, especially in the Appalachian region of the United States. In addition, this manuscript highlights an exemplary and successful professional development program for teachers in environmental education that uses contextualized pedagogies.

## Background

### *Understanding Rural Education in the USA*

The US Census (2002) defines the concept of rurality as all territory, population and housing units located outside of an urbanized area or an urbanized cluster. An urbanized area or cluster is defined in terms of a core population density of at least 1,000 people per square mile and a surrounding population density of at least 500 people per square mile.

Education in rural areas faces a number of challenges. Overall, about 30% of rural and small town schools have inadequate buildings and almost 40% of the schools reported inadequate science laboratory facilities or internet access (US General Accounting Office, 1995). In Kentucky there are almost 1,400 schools and about 632,000 students. Fifty-five percent of the school districts in this state are rural (Appalachia Regional Advisory Committee, 2005). According to the Appalachia Regional Advisory Committee (2005), 34% of Kentucky schools failed to make adequate yearly progress under No Child Left Behind (2001).

Another problem of rural areas is attracting and retaining quality teachers (Appalachia Regional Advisory Committee, 2005; Proffit, Sale, Alexander, & Andrews, 2004). Harmon (2001b) identified the causes for teacher shortages in rural areas: (a) social and cultural isolation, (b) inadequate pay, (c) limited teacher mobility, (d) lack of personal privacy, and (e) high teacher turnover. As a consequence, a significant number of teachers might be required to teach outside of their discipline (Ingersoll, 2004).

The scholarly investigation of rural education has been historically overlooked by government and academic institutions (Sherwood, 2000). Fortunately, rural education as a scholarly area of inquiry has grown significantly in the last decades (Beeson & Strange, 2003; Peroncel, 2000; Tuthill, 2000). Overall, in terms of rural education, reviews such as Kannapel and DeYoung (1999) have identified rural regions as contextually unique, noting that many

instructional improvements imported from other regions have not resulted in improved educational opportunities for rural students.

*The Challenges of Education in Appalachia*

Appalachia, a mountainous region of 23.6 million inhabitants, is formally defined by the Appalachian Regional Commission (2008) as a 205,000-square-mile region that follows the spine of the Appalachian Mountains from southern New York to northern Mississippi. It includes all of West Virginia and parts of 12 other states: Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia. Within the region, Northern, Central and Southern sub-regions have been identified. The region of interest in this paper includes Kentucky, West Virginia and northern Tennessee, known as Central Appalachia.

The Appalachian region is poorer than the national average, with the Appalachian rural areas being even poorer than their respective state averages (Appalachia Regional Advisory Committee, 2005). Specifically, 25% of children in this region live in poverty. This is relevant in that education reform efforts have yet to show significant results in poorer communities (Teets, 2006).

In Appalachia a number of disadvantageous geographical, social, economic and educational factors have coalesced. According to Ergood and Kuhre (1983), its mostly hilly terrain makes access difficult and limits the amount and quality of land available for agriculture. Its historical main industry, coal mining, has diminished in recent years, affecting the economic outlook of many families, and increasing unemployment and poverty (Mielke, 1978). Raitz and Ulack (1983) summarize the condition of Appalachia as “a region of mountains, coal mining, poverty, tourism, welfarism, isolation and subsistence agriculture” (p. 10).

Pearsall (1978) summarized the main cultural differences between the Appalachian culture and the mainstream professional culture. Appalachians typically think that humanity is subjugated to nature and God, which control people’s destiny. Consequently, a sense of fatalism and low expectations among Appalachians is commonly reported in the literature (Harmon, Henderson, & Royster 2002; Wallace, 2001). For many Appalachians, their lives are not future-oriented, so planning for an uncertain future and following up with long-term behaviors to support the plans might not be seen as a wise time investment. In this regard, Appalachians are thus present-oriented, and experience-based. This may be one reason why some Appalachians fail to see a concrete, short-term link between academic achievement and better economic opportunities (Harmon & Blanton, 1997).

Research also suggests that Appalachian life is placed in the context of particular places, possessions, human relationships and community bonds (Harmon et al., 2002). Geographic or social mobility might not be seen as a positive outcome because it might mean leaving family, friends and places behind. In addition, Appalachians tend to be very religious, and see life as something that has to be endured to reap the rewards of salvation (Keefe, 2000; McCauley, 2004). As a consequence, many perceive science with suspicion, as it frequently disagrees with Christian Biblical accounts, especially if the Christian Bible is construed as literal.

Many Appalachian families are patriarchal and women are socialized to see themselves as inferior and be subservient to males (Gochros, 1974). This has important implications for schooling as it might negatively influence a female’s decision to stay in school, excel in academics and pursue a degree in higher education (Wallace, 2000). Wallace (2001), for instance, reported that female students were significantly more likely to receive discouraging messages from family members regarding higher education compared with male students.

The Appalachian region shares many of the same problems with education as other rural regions of the United States and has some unique problems, too. For a number of Appalachian families, there is a general recognition that formal education is necessary for achievement, but many perceive schooling to be a substitute for hard work (Wallace, 2001). Simply stated, the traditional Appalachian way of life and view of higher education no longer prepares its members to face the challenges of 21st century America (Pearsall, 1978).

Educational attainment in the region is below the national average (Appalachia Regional Advisory Committee, 2005). For example, in 1980, 66.5% of Americans had a school or college qualification. For Appalachian residents, the percentage was 57.3%. Ten years later, 75.2% of Americans had a school or college qualification, compared with 68.3% of Appalachians. The latest US Census data for the year 2000 show a closing gap between American and Appalachian residents, with 80.4% and 76.8% respectively obtaining school or college qualifications (Shaw, DeYoung, & Rademacher, 2004). In Central Appalachia, the percentage of people with school or college qualifications is lower than the rest of the region (53.2% in 1990 and 64.1% in 2000).

In contrast, a widening gap is evident when the population with college or graduate qualifications is compared. In the last 30 years, the percentage of Americans with college or graduate qualifications went from 16.2% in 1980 to 24.4% in 2000. Appalachians who had college or graduate qualifications went from 11.2% in 1980 to 17.7% in 2000 (Shaw et al., 2004). In Central Appalachia, 2000 data suggest that 10.7% of the population had college or graduate qualifications.

One of the most comprehensive studies examining education in Central Appalachia was completed by Smith-Mello (2002). He concluded that several main factors are directly related to student success: (a) an innovating and caring leadership; (b) dedicated faculty; (c) supporting programs such as peer tutoring, counseling, freshman orientation and training in study skills; (d) early identification of at-risk students and implementation of successful interventions; (e) improving school accountability through better measurement and reporting; (f) providing economic incentives for students to go to college; and (g) increased cross-district communication of successful and unsuccessful instructional strategies.

In the 21st century, with the introduction of the No Child Left Behind Act (2001) and a strong emphasis on qualified teachers and accountability, school improvement initiatives and incentives for students to complete high school and enter into college increased (Shaw et al., 2004). Yet, the most recent report specifically examining the educational challenges of the Central Appalachia region identified five areas still needing improvement: (a) improving teacher and principal quality; (b) increasing outreach to and involvement of family and the community in the educational system; (c) identifying and implementing evidence-based curricula and programs; (d) building organizational and management capacity; and (e) an increased collection and use of data for assessment, improvement and accountability (Appalachia Regional Advisory Committee, 2005).

### *Scientific Literacy in Rural America*

With few exceptions, small and rural schools usually lag behind or are completely bypassed on national or state trends in science education reform (Harmon & Blanton, 1997). Part of the reason includes a number of barriers for change identified in the literature, including: (a) the beliefs and values of the teachers, administrators, community and reformers; (b) consensus regarding the means for reaching a new science education vision; (c) student expectations; (d) who initiates the move towards change and the improvement of scientific literacy; and (e) institutional and cultural constraints (Veal & Elliot, 1996).

The literature examining science literacy in rural areas is described by many researchers as limited (Henderson, 2001). There is little evidence that science education reform efforts developed for urban and suburban regions translate effectively into rural areas in general, and with students from more economically depressed areas like Appalachian. In fact, Henderson (2001) identified almost 50 topics regarding scientific literacy in Appalachia in need of urgent research, including: (a) community support for science and science education; (b) the implementation of science instructional resources given the area's remoteness, equipment cost, lack of infrastructure and lack of access; (c) the presence and role of knowledgeable leadership in science and science education; (d) pre-service science teacher preparation, induction into the profession and professional development of novice and veteran science teachers; (e) science curriculum, instruction and assessment in the context of rural schools; and (f) the interaction of sociocultural and economic variables in the attitudes about science among students and their parents.

It has been suggested that rural science education should become increasingly contextual, that is, it should be rooted in the local culture and experiences. Instead of abstract learning and memorization, a 'hands on' approach where the nearby ecosystem becomes the classroom and the knowledge is clearly applied is suggested (Eller, 2001).

#### *Scientific Literacy in Central Appalachia*

Community and education leaders have started to realize that the future economic prosperity of Appalachia and the building of a skilled workforce are tied to a better education in mathematics, science and technology (Harmon & Blanton, 1997; Harmon et al., 2002). As a consequence, a number of efforts have been implemented to improve the science literacy of Appalachian students.

Standardized test results can be used to estimate the current status of science literacy in Central Appalachia. For example, Kentucky annually offers the Commonwealth Accountability Testing System (Kentucky Department of Education, 2006, 2008). The science portion of this test is designed to measure science content knowledge, science communication skills, problem solving strategies, connection between science disciplines and deductive reasoning. The test uses four performance levels: novice, apprentice, proficient and distinguished. The Kentucky Department of Education aims for all students to be at the proficient level or better. Between 1999 and 2008, the percentage of elementary school students at the proficient level or better has increased from 33% to 69% (Table 1). At the middle school level, the increase has been from 27% to 60% (Table 2). In 1999, 26% of the high school students scored at proficient or better, compared with 44% of high school students in 2008 (Table 3).

Despite significant gains, on average, 4 out of 10 students in Kentucky have not met the goal of proficiency in science. A possible solution is research-based curricula that introduce students to the various aspects of science from a contextual and culturally-relevant perspective. This perspective is grounded in sociocultural theories of learning, which state that learning is informed and constructed by the interaction of the culture that the child brings to school, the culture of the classroom, and the social ties between and within teachers, students and the community (Alexander & Murphy, 1999; Barba, 1998).

A curriculum that is contextually relevant recognizes that knowledge is made concrete and is acquired within a specific context, that is, a set of prior experiences, beliefs, values and knowledge (Balsam, 1985; Neperud, 1995). As a consequence, students can learn better if the topics covered are embedded in a familiar sociocultural context that can help students in making the transition between the unknown and the familiar. Research suggests that reorganizing lessons to attend specifically to linguistic and cultural variations can promote educational ex-

Table 1. Science Performance Level Percentages for Elementary School Students in Kentucky

Year	Performance Level (%)			
	Novice <sup>a</sup>	Apprentice <sup>b</sup>	Proficient <sup>c</sup>	Distinguished <sup>d</sup>
1999	18.05	49.28	27.21	5.46
2000	14.41	49.66	30.41	5.52
2001	11.70	46.80	34.50	7.00
2002	11.13	47.36	34.98	6.53
2003	8.15	44.98	37.84	9.03
2004	6.93	38.07	40.78	14.26
2005	5.55	40.29	40.63	13.53
2006	7.36	35.49	39.29	17.86
2007	7.33	26.52	38.71	27.44
2008	7.29	23.79	39.69	29.23

a. Novice: Student demonstrates minimal, limited, underdeveloped, and at times inaccurate content knowledge and reasoning; student communication is ineffective and lacks detail with no evidence of connections within or between content areas; student uses strategies that are inappropriate.

b. Apprentice: Student demonstrates some basic content knowledge and reasoning ability; student communicates reasonably well but draws weak conclusions or only partially solves or describes; and student attempts appropriate strategies with limited success.

c. Proficient: Student demonstrates broad content knowledge and is able to apply it; student communication is accurate, clear, and organized with relevant details and evidence; student uses appropriate strategies to solve problems and make decisions; and student demonstrates effective use of critical thinking skills.

d. Distinguished: Student demonstrates an in-depth, extensive, or comprehensive knowledge of content; student communication is complex, concise, and sophisticated with thorough support, explicit examples, evaluations, and justifications; student uses and consistently implements a variety of appropriate strategies; and student demonstrates insightful connections and reasoning.

cellence (Cole & Griffin, 1987). Conversely, the ineffectiveness of decontextualized curricula has been documented (Erickson & Mohatt, 1982).

A curriculum that is culturally relevant values and respects the unique culture of the students, using it as a vehicle to foster learning (Banks, 1993; Banks & McGee-Banks, 1995; Grant, 1994; Nieto, 1992). In fact, Sleeter and Grant (2008), and Bennett (2007) already identified Appalachians as a distinct cultural group from the perspective of multicultural education research. This perspective has been identified by these and other researchers as a promising way to examine the challenges and possible solutions to the issue of education in Appalachia (Owens, 2000).

One way to contextualize the teaching and learning of environmental science concepts is through direct experiences using field trips. Research has shown that field trips are a valuable experience for students and increase motivation for learning (Kern & Carpenter, 1984), enthusiasm and knowledge retention (Dweck, 1986; Hall, 1996; Wheeler, 1989), and develop positive attitudes towards science and environmental concepts (Bitgood, 1989). Specifically, water quality monitoring programs, which are field-based and hands-on, have been shown to be an effective tool to improve educational achievement (Reeder, 1998).

Another way is to provide reform-based, quality professional development for teachers. Like students, teachers also have increased motivation for learning, enthusiasm and knowledge retention, and a positive attitude towards science and environmental concepts from participating in workshops that provide hands-on learning. In a survey conducted by Meichtry and Harrell (2002), K-12 teachers interested in environmental education preferred professional development workshop sites with hands-on learning opportunities for both the teacher and

Table 2. Science Performance Level Percentages for Middle School Students in Kentucky

Year	Performance Level (%)			
	Novice <sup>a</sup>	Apprentice <sup>b</sup>	Proficient <sup>c</sup>	Distinguished <sup>d</sup>
1999	34.08	38.45	20.89	6.59
2000	32.87	38.75	21.35	7.03
2001	30.85	39.11	22.03	8.01
2002	28.22	38.56	23.57	9.65
2003	28.68	37.52	22.83	10.97
2004	23.51	35.66	25.99	14.84
2005	23.53	35.84	27.18	13.46
2006	22.23	35.05	26.23	16.49
2007	11.16	32.89	39.83	16.13
2008	10.42	30.03	41.98	17.57

a. Novice: Student demonstrates minimal, limited, underdeveloped, and at times inaccurate content knowledge and reasoning; student communication is ineffective and lacks detail with no evidence of connections within or between content areas; student uses strategies that are inappropriate.

b. Apprentice: Student demonstrates some basic content knowledge and reasoning ability; student communicates reasonably well but draws weak conclusions or only partially solves or describes; and student attempts appropriate strategies with limited success.

c. Proficient: Student demonstrates broad content knowledge and is able to apply it; student communication is accurate, clear, and organized with relevant details and evidence; student uses appropriate strategies to solve problems and make decisions; and student demonstrates effective use of critical thinking skills.

d. Distinguished: Student demonstrates an in-depth, extensive, or comprehensive knowledge of content; student communication is complex, concise, and sophisticated with thorough support, explicit examples, evaluations, and justifications; student uses and consistently implements a variety of appropriate strategies; and student demonstrates insightful connections and reasoning.

student. In addition, field trips allow for more sharing of ideas. Establishing an atmosphere that encourages the learners to create a group to support their professional development through meetings and discussions is a valuable tool in professional development programs (Monroe et al., 2005). This is often accomplished when educators are participating in activities and share ideas on how to best implement them in the classroom.

### Reading the Rivers: Exemplary Scientific Literacy in Appalachia

This section aims at sharing experiences and impact of an exemplary program that integrates sociocultural and contextual viewpoints into environmental education. A detailed report of the success of the Reading the River program has been published (see Meichtry & Smith, 2007). The following paragraphs describe the project and its main findings. This project was selected by the authors because it is a commendable effort that can be replicated in similar rural areas both nationally and internationally.

Dr. Yvonne Meichtry, previously of Northern Kentucky University, and Dr. Robert Boram, Morehead State University, co-developed the Reading the River program in the late 1990s. The program's title was inspired by renowned conservationist's Aldo Leopold's concept of reading the landscape to discover and understand the natural and human forces that shape the environment. The objectives of the program were to increase the level of confidence and degree to which the teachers (a) use hands-on inquiry-based teaching, (b) integrate the

Table 3. Science Performance Level Percentages for High School Students in Kentucky

Year	Performance Level (%)			
	Novice <sup>a</sup>	Apprentice <sup>b</sup>	Proficient <sup>c</sup>	Distinguished <sup>d</sup>
1999	32.13	42.27	23.84	1.76
2000	30.81	41.87	25.19	2.13
2001	28.52	42.61	26.58	2.29
2002	27.01	41.69	27.92	3.38
2003	27.88	41.71	27.09	3.33
2004	23.86	40.39	31.66	4.09
2005	22.38	40.30	33.41	3.91
2006	23.66	37.25	34.19	4.89
2007	17.78	40.57	35.48	5.78
2008	20.32	38.42	28.36	15.38

a. Novice: Student demonstrates minimal, limited, underdeveloped, and at times inaccurate content knowledge and reasoning; student communication is ineffective and lacks detail with no evidence of connections within or between content areas; student uses strategies that are inappropriate.

b. Apprentice: Student demonstrates some basic content knowledge and reasoning ability; student communicates reasonably well but draws weak conclusions or only partially solves or describes; and student attempts appropriate strategies with limited success.

c. Proficient: Student demonstrates broad content knowledge and is able to apply it; student communication is accurate, clear, and organized with relevant details and evidence; student uses appropriate strategies to solve problems and make decisions; and student demonstrates effective use of critical thinking skills.

d. Distinguished: Student demonstrates an in-depth, extensive, or comprehensive knowledge of content; student communication is complex, concise, and sophisticated with thorough support, explicit examples, evaluations, and justifications; student uses and consistently implements a variety of appropriate strategies; and student demonstrates insightful

sciences, (c) integrate science with other subject areas, (d) use community-based resources, (e) use the local environment, (f) teach real world current issues, (g) use technology in their teaching, (h) conduct field-based investigations, and (i) teach watershed topics (Meichtry & Smith, 2007).

The first offering of the program was in 2001. The program has been successfully administered for five years in the Licking River watershed. The watershed covers 21 counties in eastern Kentucky. The program has had teachers participating from all of the counties where the watershed is located, in addition to neighboring counties in eastern and central Kentucky, as well as southern Ohio. The teachers that have participated in the program ranged from primary to high school. A majority of the teachers were science and/or math teachers. The workshop is offered as a separate program or can be taken for graduate or upper college level credit.

*Program Description*

Reading the River consists of a one-week hands-on, inquiry-based summer workshop. The educators travel by canoe and van during a six-day field trip through the Licking River watershed; teachers are challenged to make new observations while learning about the biology, geology, land use, history and the culture of the Licking River watershed. Water quality was the unifying concept of the program.

Content area specialists representing several state and local agencies are scheduled throughout the program to share their expertise on nonpoint source water pollution in relation to land use, history and culture. At no financial cost to the teachers, they learn biological,



physical and chemical water monitoring techniques, while integrating biology, chemistry, geology, physical science, social studies, practical living and mathematics. Teachers that participate in the workshop are also required to attend two follow-up sessions during the academic year. The follow-up sessions allow them to refine and share the lessons and curricular materials developed as a result of the workshop. The teachers participated in additional training. The program is funded and supported through a variety of sources, including local, state and federal agencies, non-profit organizations and private businesses.

The field trip begins at the Magoffin County headwaters of the 300 mile long Licking River. Participants are immediately immersed in the watershed, making observations and collecting data. They are also introduced to the local culture and heritage. Moving downstream, participants visit Cave Run Lake in Rowan and Bath counties to learn about the economic and environmental impacts of this 8,300-acre impoundment. Land use changes and the impact of land use on water quality are observed and examined as the educators travel from upland coal-

Table 4. Typical schedule of events for the Reading the River program.<sup>a</sup>

Day	Activities
1	Training and watershed overview (Stream volume and flow rate, chemical monitoring, macroinvertebrate sampling techniques, habitat assessment, plankton and fecal coliform sampling techniques, geological positioning system).
2	Geology, biology, and botany of the headwaters Stream monitoring (Site 1 at headwaters and downstream sites, site 2, and site 4) County Historical Society tour Legal aspects of water quality protection Clean Water Act and state regulations
3	National Forest practices related to watershed management Forestry Service resources for teachers Fishes of KY presentation Tours: Dam and fish hatchery Electrofishing fish identification Pontoon study of lake created by dam (Aquatic productivity, chemistry profile, plankton sampling) Wetlands overview at national park site
4	Mussel classroom presentation Mussel field study at river site Stream monitoring (site 4 and site 5). Downstream canoe trip (12 miles) State park museum and history presentation of river
5	River watershed management framework Canoeing and stream monitoring at state park Site 6 Flooding history and effects at local flood site Stream monitoring Site 7 Farm site: Agricultural best practices along the river system Stream monitoring Site 8 at farm Kentucky Waters music program
6	Microanalysis of plankton collected during workshop Reflections and stream sampling Site 9 at the mouth of the river Storm water management in urban area and education outreach of water treatment agency Summary of data collection throughout week

a. From Meichtry, Y. & Smith, J. (2007). The impact of a place-based professional development program on teachers' confidence, attitudes, and classroom practices. *The Journal of Environmental Education*, 38(2), 15-34.

bearing areas downstream through agricultural lands, finally reaching the urbanized area near the Licking River's confluence with the Ohio River in Northern Kentucky, near Cincinnati, Ohio. A detailed description of each day's activities is presented in Table 4. This in-depth, sequential analysis of a local ecosystem was carefully designed to address some of the shortcomings in the preparation of contextually-aware science teachers, as described in the literature (Eller, 2001; Henderson, 2001; Owens, 2000; Reeder, 1998; Sleeter & Grant, 2008).

### *Evidence of Success*

The program has used a variety of tools to measure the success of the program in terms of its main objectives, that is, impact on teachers' confidence and quality of the program's instruction. The researchers prepared a pre-test (administered the first day of the project) and a post-test (administered the last day of the project). The same post-test was administered nine months later to assess the long-term impact of the program. These assessments included a section for participants to write comments and 5-point Likert-type scales. The responses were 1 (very low), 2 (low), 3 (average), 4 (high), and 5 (very high). This scale was chosen because it is one of the most commonly used scaling techniques, has been shown to be reliable, valid, and responsive, it is easy to use and understand by the researcher and the participant, and its coding and interpretation is straightforward (Hasson & Arnetz, 2005; Jaeschke, Singer, & Guyatt, 1990; Svensson, 2000; Vickers, 1999). Despite some of the limitations discussed in the literature (e.g., wording of the response alternatives might affect participants' responses, might not be appropriate for complex subjective scenarios), the Likert scale was perceived as a better option than other scaling techniques, such as visual analogue scales (McCormack, Horne, & Sheather, 1988). Meichtry and Smith (2007) reported that the internal consistency reliabilities of the assessment items grouped by theme were: 0.79 (technology), 0.85 (teaching and instructional strategies), 0.82 (community resources), 0.82 (conducting field-based investigations), and 0.83 (ability to teach watershed topics). In addition, the researchers interviewed some of the participants.

Below is a summary of the pre- and post- evaluation results. The authors are only highlighting responses with significantly different means between the pre and post results. Statistical details from the MANOVA analysis, including F and p values are available from Meichtry and Smith, 2007.

Teachers showed statistically significant improved confidence in the use of many instructional technologies, such as water quality sampling kits, labware, probes, graphic calculators, microscopes, videoscopes, presentation software (Powerpoint), and digital cameras. Their confidence in using internet web sites for research and support materials did not change during the duration of the project.

In terms of the participants' confidence in the use of instructional strategies, they significantly improved in addressing gender and minority equity and integrating science as a subject with other subject areas. Their confidence in using hands-on instructional strategies, using inquiry-based teaching strategies, and integrating the sciences in teaching remained about the same throughout the project.

Teachers significantly improved their confidence in using community resources. Three examples of these are guest speakers, visiting natural environment field sites related to watershed studies, and leading field trips to watershed-related community resource sites. Similar gains were observed in their confidence to conduct field investigations, such as water chemistry, and macroinvertebrate, fish, and geology studies. Furthermore, the participants reported increased confidence in their ability to teach watershed topics, and connections between science/real life, science/societal issues, and science/science careers.

In addition to the pre- and post- assessments, several open ended questions were asked. The first question was: What do you consider to be the strengths of this program? The hands-on approach of teaching the workshop, the wealth of resources available to them, and the opportunity to network with field experts were commonly cited as strengths of the program. When asked “What do you consider to be the single most beneficial aspect of this program?” frequent responses included: (a) learning experientially so that teachers can teach students in the same manner; (b) learning about different resources and how to effectively use them; (c) receiving material and resources to take back to the classroom, allowing integration of knowledge gained into instructional practices; (d) gaining knowledge that gives confidence in teaching unfamiliar content; (e) becoming more aware of local problems with watersheds; (f) networking with people and agencies that can help participants to teach water topics; and (g) connecting a multitude of water-related issues and real world applications.

The ultimate goal for improving teaching skills and quality of teaching is, of course, improving student learning. Nine months after the summer project was completed, participants were asked “Did your participation in the program help to improve your students’ learning? If yes, describe the impact of the program on your students’ learning.” Many teachers cited that the students were more aware of their environment and the effects the community has on the local creeks and rivers. Others stated that the hands-on teaching approach, especially when field work was integrated, resulted in a positive way to help the students to remember. Teachers agreed that the strategies and content modeled by the Reading the River staff and field experts would definitely increase student comprehension and connections to real life issues and responsibilities. The teachers were also able to incorporate water quality studies with nearby school ponds.

## **Conclusion**

Rural science education, especially for students from economically depressed areas like Appalachia, presents a series of impressive challenges that are currently being addressed through the efforts of students, teachers, school administrators, community leaders and education agencies. The Reading the River program, designed to provide quality field-based, hands-on professional development in environmental education (as recommended by Meichtry & Harrell, 2002) in which communication, dialogue, and analysis is in-depth and on-going through the week of activities (as recommended by Monroe et al., 2005) has increased the level of confidence of teachers in regards to how they (a) use hands-on inquiry-based teaching, (b) integrate the sciences, (c) integrate science with other subject areas, (d) use community-based resources, (e) use the local environment, (f) teach real world current issues, (g) use technology in their teaching, (h) conduct field-based investigations, and (i) teach watershed topics. The design, implementation and positive findings of Reading the River are consistent with similar studies that incorporated contextual and culturally relevant experiential education, using local settings, community-based experts, and reflective practice (Ciffone, Morelock, Turner, Sivek, & Daudi, 2002; Lieberman & Hoody, 1998; Meichtry & Smith, 2007).

Of course, the success of Reading the River must be examined in the context of potential methodological and data collection limitations. Self-selection for participation and self-reported data that are not compared with direct follow-up classroom observations of science teachers implementing what was learned in the project must be disclosed for the proper analysis and generalization of the findings. Overall, the teachers’ increase in both subject matter and pedagogical content knowledge (Appalachia Regional Advisory Committee, 2005) within

the unique context of Appalachia (Kannapel & DeYoung, 1999) represents a replicable program that uses contextual and cultural relevance to ensure the scientific literacy of both students and teachers.

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### References

- Alexander, P.A., & Murphy, P.K. (1999). What cognitive psychology has to say to school psychology: Shifting perspectives and shared purposes. In C.R. Reynolds, and T.B. Gutkin, *The handbook of school psychology* (3<sup>rd</sup> ed.). New York: John Wiley & Sons.
- American Association for the Advancement of Science. (1994). *Benchmarks for science literacy*. New York: Oxford University Press.
- Appalachia Regional Advisory Committee. (2005). *Report on educational challenges and technical assistance needs for the Appalachian region*. Washington, DC: US Department of Education. Retrieved 15 December, 2008, from <http://www.ed.gov/about/bdscomm/list/rac/index.html>
- Appalachian Regional Commission. (2008). *The Appalachian region*. Retrieved 15 December, 2008, from <http://www.arc.gov/index.jsp>
- Balsam, P.D. (1985). The functions of context in learning and performance. In P.D. Balsam and A. Tomie (Eds.), *Context and learning* (pp. 1-22). Hillsdale, NJ: Lawrence Erlbaum.
- Banks, J.A. (1993). Multicultural education: Development, dimensions, and challenges. *Phi Delta Kappan*, 75(1), 22-28.
- Banks, J.A., & McGee-Banks, C.A. (1995). *Handbook of research on multicultural education*. New York: Macmillan.
- Barba, R.H. (1998). *Science in the multicultural classroom: A guide to teaching and learning* (2nd ed.). Needham Heights, MA: Allyn & Bacon.
- Beeson, E., & Strange, M. (2003). *Why rural matters: The continuing need for every state to take action on rural education*. Washington, DC: Rural School and Community Trust.
- Bennett, C.I. (2007). *Comprehensive multicultural education: Theory and practice*. Boston: Pearson Allyn & Bacon.
- Bitgood, S. (1989). School field trips: An overview. *Visitor Behavior*, 4(2), 3-6.
- Ciffone, E., Morelock, J., Turner, K., Sivek, D., & Daudi, S. (2002). Using community resources in environmental education. In J. Heimlich (Ed.), *Environmental education: A resource handbook* (pp. 39-43). Bloomington, IN: Phi Delta Kappa.
- Cole, M., & Griffin, P. (1987). *Contextual factors in education: Improving science and mathematics education for minorities and women*. Madison, WI: Wisconsin Center for Education Research.
- Duschl, R.A. (1990). *Restructuring science education: The importance of theories and their development*. London: Teachers College Press.
- Dweck, C.S. (1986). Motivation processes affecting learning. *American Psychologist*, 41, 1040-1048.

- Eller, R. (2001). The rural condition in contemporary Appalachia. In S. Henderson (Ed.). *Understanding achievement in science and mathematics in rural schools* (pp. 39-41). Lexington, KY: Appalachian Rural Systemic Initiative.
- Ergood, B., & Kuhre, B.E. (1983). Why study Appalachia? In B. Ergood & B.E. Kuhre (Eds.), *Appalachia: Social context past and present* (pp. 3-7). Dubuque, IA: Kendall Hunt.
- Erickson, F., & Mohatt, G. (1982). Cultural organization of participant structures in two classrooms of Indian students. In G.D. Spindler (Ed.), *Doing the ethnography of schooling* (pp. 132-174). New York: Holt, Rinehart & Winston.
- Gallagher, J.J. (1989). Research on secondary school science practices, knowledge and beliefs: A basis for restructuring. In M.L. Matyas, K.G. Tobin & B.J. Fraser (Eds.), *Looking into windows: qualitative research in science education* (pp. 43-57). Washington, DC: American Association for the Advancement of Science.
- Gochros, H.L. (1974). Sex and marriage in rural Appalachia. In F.S. Riddel (Ed.), *Appalachia: Its people, heritage, and problems* (pp. 77-80). Dubuque, IA: Kendall/Hunt.
- Grant, C.A. (1994). Challenging the myths about multicultural education. *Multicultural Education*, 2(2), 4-9.
- Hall, D.W. (1996). Bringing hands-on experience to teaching insect field biology. *Journal of College Science Teaching*, 24, 195-200.
- Harmon, H. (2001a). Education issues in rural schools in America. In S. Henderson (Ed.). *Understanding achievement in science and mathematics in rural schools* (pp. 17-24). Lexington, KY: Appalachian Rural Systemic Initiative.
- Harmon, H. (2001b, March). *Attracting and retaining teachers in rural areas*. Paper presented at the annual meeting of the American Association of Colleges for Teacher Education, Dallas, TX.
- Harmon, H., & Blanton, R. (1997, September). *Strategies for improving math and science achievement in rural Appalachia*. Paper presented at the 89th National Rural Education Association convention, Tucson, AZ.
- Harmon, H., Henderson, S., & Royster, W. (2002). Reforming math and science in rural schools. *Principal Leadership*, 2(5), 28-32.
- Hasson, D., & Arnetz, B.B. (2005). Validation and findings comparing visual analogue scales vs. Likert scales for psychosocial measured. *International Electronic Journal of Health Education*, 8, 178-192.
- Henderson, S. (2001). *Understanding achievement in science and mathematics in rural schools*. Lexington, KY: Appalachian Rural Systemic Initiative.
- Howley, C. (2001). Understanding the circumstances of rural schooling: The parameters of respectful research. In S. Henderson (Ed.). *Understanding achievement in science and mathematics in rural schools* (pp. 11-16). Lexington, KY: Appalachian Rural Systemic Initiative.
- Ingersoll, R.M. (2004). *Why some schools have more underqualified teachers than others?* Baltimore, MD: Brookings Institute Press.
- Jaeschke, R., Singer, J., & Guyatt, G. H. (1990). A comparison of seven-point and visual analogue scales. Data from a randomized trial. *Controlled Clinical Trials*, 11(1):43-51.
- Kannapel, P.J., & DeYoung, A.J. (1999). The rural school problem in 1999: A review and critique of the literature. *Journal of Research in Rural Education*, 15(2), 67-79.
- Keefe, S.E. (2000, March). *Mountain identity and the global society in a rural Appalachian county*. Paper presented at the National Conference on Ethnicity and Gender in Appalachia, Huntington, WV.
- Kentucky Department of Education. (2006). *Commonwealth accountability testing systems briefing report 2008*. Frankfort, KY: Kentucky Department of Education. Retrieved 15 December, 2008, from <http://www.kde.state.ky.us/KDE>.

- Kentucky Department of Education. (2008). *Commonwealth Accountability Testing Systems Briefing Report 2006*. Frankfort, KY: Kentucky Department of Education. Retrieved 15 December, 2008, from, <http://www.kde.state.ky.us/KDE>.
- Kern, E., & Carpenter, J. (1984). Enhancement of student values, interest, and attitudes in earth science through a field-oriented approach. *Journal of Geological Education*, 32, 299-305.
- Lieberman, G., & Hoody, L. (1998). *Closing the achievement gap: Using the environment as an integrating context for learning*. San Diego, CA: State Environment and Education Roundtable.
- McCauley, D.V. (2004). Appalachian religion. In R.A. Straw & H. Tyler Blethen (Eds.), *High mountains rising: Appalachia in time and place* (pp. 179-196). Chicago, IL. University of Illinois Press.
- McCormack, H.M., Horne, D.J., & Sheather, S. (1988). Clinical applications of visual analogue scales: a critical review. *Psychological Medicine*, 18(4), 1007-1019.
- Meichtry, Y., & Harrell, L. (2002). An environmental education assessment of K-12 teachers in Kentucky. *The Journal of Environmental Education*, 33(3), 21-26.
- Meichtry, Y., & Smith, J. (2007). The impact of a place-based professional development program on teachers' confidence, attitudes, and classroom practices. *The Journal of Environmental Education*, 38(2), 15-34.
- Mielke, D.N. (1978). *Teaching mountain children: Towards a foundation of understanding*. Boone, NC: Appalachian Consortium Press.
- Monroe, M., Seitz, J., Agrawal, S., Aldridge, M., Morshed, S., Swiman, E., & Crisp, V. (2005). *Improving Inservice Teacher Workshops in Florida*. University of Florida IFAS Extension Newsletter. Retrieved 15 December, 2008, from, <http://edis.ifas.ufl.edu/pdf/files/FR/FR15700.pdf>.
- National Research Council. (1996). *National science education standards*. Washington, DC: National Academies Press.
- Neperud, R.W. (1995). Transition in art education: A search for meaning. In R.W. Neperud (Ed.), *Context, content, and community in art education: Beyond postmodernism* (pp. 3-24). New York, NY: Teachers College Press.
- Nieto, S. (1992). *Affirming diversity: The sociopolitical context of multicultural education*. New York: Longman.
- No Child Left Behind Act (2001). *20 USCA § 6301 et seq.*
- Owens, W.T. (2000). Country roads, hollers, coal towns, and much more: A teacher's guide to teaching about Appalachia. *The Social Studies*, 91(4), 178-186.
- Pearsall, M. (1978). Communicating with the educationally deprived. In D.N. Mielke (Ed.), *Teaching mountain children: Towards a foundation of understanding* (pp. 59-66). Boone, NC: Appalachian Consortium Press.
- Perroncel, C.B. (2000). *Getting kids ready for school in rural America*. Washington, DC: United States Department of Education.
- Proffit, A.C., Sale, R.P., Alexander, A.E., & Andrews, R.S. (2004). The Appalachian Model Teaching Consortium: Preparing teachers for rural Appalachia. *The Rural Educator*, 26(1), 24-29.
- Raitz, K.B. & Ulack, R. (1983). Appalachia: Regional definitions. In B. Ergood & B. E. Kuhre (Eds.), *Appalachia: Social context past and present*. Dubuque, IA: Kendall Hunt.
- Reeder, B.C. (1998). Using water quality monitoring as a university-level teaching tool. *Journal of the Kentucky Academy of Science*, 59(1), 6-11.
- Roberts, D. (2007). Scientific literacy/science literacy. In S.K. Abell & N.G. Lederman (Eds.), *Handbook of research on science education* (pp. 729-780). Mahwah, New Jersey: Lawrence Erlbaum.
- Roehrig, G.H., & Luft, J.A. (2004). Constraints experienced by beginning secondary science teachers in implementing scientific inquiry lessons. *International Journal of Science Education*, 26(1), 3-24.

- Shaw, T.C., DeYoung, A.J., & Rademacher, E.W. (2004). Educational attainment in Appalachia: Growing with the nation, but challenges remain. *Journal of Appalachian Studies*, 10(3), 307-329.
- Sherwood, T. (2000). Where has all the "Rural" gone? Rural education research and current federal reform. *Journal of Research in Rural Education*, 16(3), 159-167.
- Sleeter, C.E., & Grant, C.A. (2008). *Making choices for multicultural education: Five approaches to race, class, and gender* (6th ed.). Hoboken, NJ: John Wiley & Sons.
- Smith-Mello, M. (2002). *Listening to Kentucky high schools: Why some high schools miss, meet, and exceed predicted postsecondary outcomes*. Frankfort, KY: Kentucky Long Term Policy Research Center.
- Songer, N.B., Lee, H.S., & McDonald, S. (2003). Research towards an expanded understanding of inquiry science beyond one idealized standard. *Science Education*, 87(4), 490-516.
- Svensson, E. (2000). Comparison of the quality of assessments using continuous and discrete ordinal rating scales. *Biometrical Journal*, 42(4), 417-434.
- Teets, S. (2006). Education in Appalachia. In G.T. Edwards, J.A. Asbury, & R. L. Cox (Eds.), *A handbook to Appalachia* (pp. 119-142). Knoxville, TN: University of Tennessee Press.
- Tuthill, S.J. (2000). *Innovative approaches in rural education*. Beltsville, MD: National Agricultural Library.
- US Census (2002). *Rural and urban classification*. Retrieved 12 December 2008 from [http://www.census.gov/geo/www/ua/ua\\_2k.html](http://www.census.gov/geo/www/ua/ua_2k.html)
- US General Accounting Office. (1995). *School facilities: America's schools not designed or equipped for 21st century*. GAO/HEHS-95-95. Washington, DC: GAO, April.
- Veal, W.R., & Elliot, T.D. (1996). *Science education reform in a rural county*. (ERIC Document Reproduction Service No. ED 407 812).
- Vickers, A.J. (1999). Comparison of an ordinal and a continuous outcome measure of muscle soreness. *International Journal of Technology Assessment in Health Care*, 15(4), 709-716.
- Victor, E., Kellough, R.D., & Tai, R.H. (2008). *Science K-8: An integrated approach*. Upper Saddle River, NJ: Pearson Prentice Hall.
- Wallace, L.A. (2000, October). "The ABC of Appalachia": A descriptive view of perceptions of higher education in Appalachian culture. Paper presented at the second annual conference of the Women of Appalachia: Their heritage and accomplishments, Zanesville, OH.
- Wallace, L.A. (2001, October). *The story of one, a reflection of many: Lessons learned from an Appalachian heritage*. Paper presented at the third annual conference of the Women of Appalachia: Their heritage and accomplishments, Zanesville, OH.
- Wheater, C.P. (1989). A comparison of two formats for terrestrial behavioral ecology field courses. *Journal of Biological Education*, 23, 223-229.

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