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ABSTRACT

The research base for science and mathematics education in rural school contexts is extremely limited. Education reform movements have generally been unresponsive to the unique qualities of rural schools, and many national and state reform leaders continue to ignore the importance of local contexts. A conference was held in May 2001 to identify a research agenda for the study of factors impacting student learning and student achievement in mathematics and science in rural school environments. This proceedings contains a summary of conference discussions, five commissioned papers, and two additional "overview presentations." Questions that emerged during discussion groups were grouped into seven categories: community support, instructional resources, leadership and school reform, professional development, preservice education and induction, curriculum and instruction, and databases. The papers are "Understanding the Circumstances of Rural Schooling: The Parameters of Respectful Research" (Craig B. Howley); "Education Issues in Rural Schools of America" (Hobart Harmon); "Science Education Contextual Issues" (Robert E. Yager); "'Best Practices' in Mathematics Education from an International Perspective" (Curtis McKnight); "Learning Technology: Contextual Issues Prepared for the Appalachian Rural Systemic Initiative" (Cheryl Lemke); "The Rural Condition in Contemporary Appalachia" (Ron Eller); and "Why Research on Science and Mathematics Education in Rural Schools Is Important or the Mean Is the Wrong Message" (Edward Kifer). A list of participants is included. (SV)

arsi Appalachian Rural Systemic Initiative

Understanding Achievement in Science and Mathematics in Rural Schools

Conference Proceedings
Edited by

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Lexington, Kentucky

About ARSI
(Appalachian Rural Systemic Initiative)
"Empowering Appalachian Children With Mathematics and Science"

The Appalachian Rural Systemic Initiative (ARSI) is a National Science Foundation (NSF) funded initiative designed to improve the performance of K-12 students in mathematics and science by strengthening the knowledge and skills of local teachers. The ARSI project utilizes a highly interactive network of regional, state, and local educators to provide the resources needed to deliver challenging science and mathematics curricula in rural schools in high poverty counties of Appalachia. ARSI impacts 66 disadvantaged counties in Kentucky, North Carolina, Ohio, Tennessee, Virginia and West Virginia.

Resource Collaboratives

The five Resource Collaboratives, strategically located at area universities, spearhead ARSI's reform efforts. As "field agents," the Collaboratives facilitate local planning and decision-making while coordinating training for Teacher Partners and direct services to catalyst schools in their region. ARSI's goal is to embed the functions of the resource collaborative within each university so that these sites will continue as centers for science and mathematics education reform beyond the scope of NSF support.

Teacher Partners

ARSI has developed a strong network of committed and competent Teacher Partners in participating districts. Teacher Partners have become the primary change agents for reform. In catalyst schools and other schools in their districts, Teacher Partners help other teachers implement standards-based instruction and provide support for curriculum development and selection of resources.

Professional Development

The primary strategy for change in schools in the region has been the professional development of mathematics and science teachers. Teachers in area schools show:

- Attitudes that are consistent with standards-based mathematics and science and
- Stronger preparation and more frequent classroom use of standards-based practices.

Community Partnerships

Support for ARSI's vision of high-quality, standards-based programs is widespread and improving steadily among stakeholder groups in the participating districts. ARSI Teacher Partners are active in building community support, which is enhancing understanding and involvement in school math and science programs. Activities that have helped schools reach out to the community include community meetings, family mathematics/science/technology nights and the use of community and business leaders and parents on community engagement teams.

The ARSI model has proven to be a successful reform strategy in math and science education for the Appalachian Region. More than ever before, rural prosperity depends on increasing rural peoples' access to educational opportunities. Although ARSI is closing the gap in student achievement and building capacity for leadership, continued improvement in the Appalachian regions is vitally important as there is still much to be done. It can only be accomplished by collaborative involvement of all stakeholders.

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- Wimberly Royster, Principal Investigator
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We also appreciate the feedback provided by the participants as we edited the questions and particularly thank Michael Wavering for his thoughtful assistance in formatting and developing the "Conference Outcomes" section.

The funds for the *Understanding Achievement in Science and Mathematics in Rural School Settings Conference* were provided through a grant from the National Science Foundation, Division of Education and Human Resources.

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APPALACHIAN RURAL SYSTEMIC INITIATIVE

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A Message From ARSI

Dear Reader:

The purpose of this publication is to put forth issues and stimulate new research regarding *Understanding Achievement in Science and Mathematics in Rural School Settings.* This collection of commissioned papers and summeries was prepared by people who have experience in education from the rural context and people who are experienced in mathematics, science and technology contextual issues.

Over the past six years, the Appalachian Rural Systemic Initiative (ARSI) has been involved in working with economically disadvantaged rural K-12 schools in Central Appalachia to improve teaching and learning at the school level. During this period, we have observed that there is a lack of understanding and research on the teaching and learning of science and mathematics in these and comparable rural school systems. Thus we invited a group interested in these issues to help us identify and define more clearly the researchable issues. We hope this report will generate interest among mathematics and science educators.

Sincerely,

Wimberly C. Royster

ARSI Principal Investigator

Wimberly Royster

After retiring in 1992 as Vice President for Research and Graduate studies at the University of Kentucky, Dr. Royster joined the Kentucky Science and Technology Corporation, a non-profit corporation, to become statewide Director of the Kentucky EPSCoR program, a program of 7 federal agencies to stimulate competitive research. Subsequently, in 1993 he became involved with the NSF Rural Systemic Initiatives and currently is Principal Investigator for the Appalachian Rural Systemic Initiative (ARSI). In addition, he serves as co-director of the Appalachian Rural Education Network (AREN), a $1.1M place-based education program in Central Appalachia funded by the Rural School and Community Trust (formerly Annenberg), which overlaps with several ARSI school districts.

Understanding Achievement in Science and Mathematics in Rural School Settings

Establishing a Research Agenda that Focuses on Science and Mathematics Education in Schools in Rural School Environments

Foreword

A review of the literature indicates that there has been a lack of focus and consistency in the study of schools in rural environments. In addition, there is disagreement among rural education scholars regarding not only the purpose of education in these settings but the approach to reforms. *"The strengths and needs of rural schools have been largely ignored at the national level in conversations about school reform. At the heart of the problem is the conflict over the purpose of schooling, with state and national reform leaders typically calling for schools to prepare students to contribute to national interests, while rural education scholars believe rural school should also serve local community interests."* (Kannapel and DeYoung, 1999)

Responding to this "research void," the Appalachian Rural Systemic Initiative (ARSI) obtained funds from the National Science Foundation to conduct a working conference for the purpose of *identifying questions which will both stimulate and focus research on science and mathematics teaching and learning in rural school environments.* The conference was held in Lexington, Kentucky on May 21-23, 2001, and was attended by mathematics, science, and rural educators from across the country.

It is hoped that the results of this conference will be used to guide the research efforts of individuals and institutions interested in rural education and significantly add to the knowledge of "what works in rural schools." The "researchable questions," identified by the educators assembled at the conference, establish the framework for a *research agenda* which specifically focuses on the factors which are thought to influence student achievement in mathematics and science. The "research agenda" will be implemented by the Appalachian Rural Systemic Initiative (ARSI) and the institutions of higher education serving the region. This document will be circulated among mathematics and science education researchers in rural school settings across the country in the hope that a significantly enhanced data base will developed.

"...stimulate and focus research on science and mathematics teaching and learning in rural school environments."

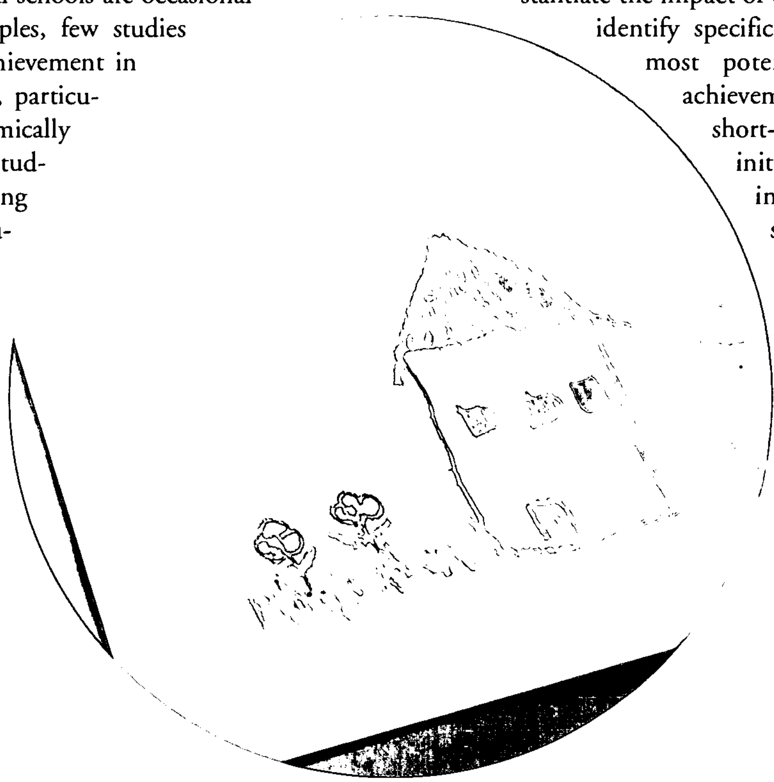
Introduction

Mathematics and Science Education Research in Rural School Settings

The research base for science and mathematics education in rural school contexts is extremely limited. Few reform efforts are tailored for rural schools and there is little evidence that "what works" in urban and suburban environments, will in fact initiate change in rural communities. Little research related to rural schools appears to focus on student learning in content areas such as science or mathematics. *"Much of the rural education literature today appears at the surface as a nostalgic tribute to the small, rural community schools of days gone by, coupled with chagrin at the historic (and still prevalent) attitude that rural schools and rural ways of life represent ignorance and provincialism."* (Sher, 1995)

Education reform movements have generally been unresponsive to the uniqueness of rural schools and have typically used generic improvement strategies, tested only in urban or suburban environments, in efforts to improve learning opportunities for students. Although rural schools are occasionally selected in research samples, few studies have focused on student achievement in the context of rural schools, particularly those in more economically depressed areas. Even fewer studies examine factors influencing mathematics and science education in these schools. According to a review of rural education literature conducted by Patricia Kannapel and Alan DeYoung in 1999, reform efforts in rural schools have generally ignored *the context in which instruction is delivered* and have not resulted in improved education opportunities for students. *"Not mindful that a century of generic reforms unresponsive to local contexts has proven inadequate, many national and state school reform leaders today continue to suggest that schools across the country are plagued by generic sorts of problems, that once again, can be fixed with generic sorts of solutions."* (Kannapel and DeYoung, 1999) The review also notes that *"much useful research in rural education is never identified as such and/or is published mostly within state department documents."* (Kannapel and DeYoung, 1999).

It was anticipated that the research questions, established during the conference, will both encourage and guide additional research studies related to mathematics and science education in rural schools. The results of these research efforts can substantiate the impact of ongoing reform efforts as well as identify specific interventions which have the most potential for improving student achievement. It is critical that that both short-term and long-term studies be initiated which can determine the important elements impacting student learning in science and mathematics in rural school environments.



...reform movements have generally been unresponsive to the uniqueness of rural schools

A Strategy for Establishing a Common Research Agenda

The overall goal of the Understanding Achievement in Science and Mathematics in Rural School Settings conference was to *"identify and publish a 'research agenda' for the study of factors impacting the student learning process and student achievement in science and mathematics in rural school environments."* The conference attendees included rural, science, mathematics, and technology educators from across the country representing universities, public schools, and Rural Systemic Initiatives.

The specific objectives for the conference were as follows:

To bring together knowledgeable rural education "experts" and persons experienced in mathematics and science education for the purpose of establishing a common research basis and agenda.

To identify clearly, in an open dialogue, research issues and questions from which a research agenda for K-12 mathematics and science education in rural environments can be crafted.

To assess the quality of the research ideas and strategies identified through feedback from "practitioners" whose primary responsibility is the improvement of mathematics and science educational programs for students in K-12 schools serving rural communities, i.e., a reality check from the field.

To recommend a "research agenda" to be distributed to researchers interested in the teaching and learning of science and mathematics education in rural environments. The "agenda" will be distributed via the ARSI Website and a conference "proceedings."

The conference was held over a 2 1/2 day period divided into two phases. In Phase I, the "Research Project Advisory Council," consisting of a small group of education leaders from rural, mathematics and science content areas, met in a working session to discuss issues and questions related to improving mathematics and science education in rural schools with the expressed purpose of developing a *preliminary set of researchable questions*. Five commissioned papers focusing on "current issues," written by leading practitioners in the fields of science, mathematics, technology, and rural education, provided direction for the discussion and the development of the researchable questions. These questions were compiled and published as a draft to serve as a guide for discussion and further development by the "invited participants" attending Phase II of the conference.

Phase II of the conference consisted of "overview presentations" focusing on both rural and science/mathematics issues, a general discussion of the *preliminary draft* of the researchable questions, small group analysis and refinement sessions, and a final general session to clarify the final draft of the research questions.

The *researchable questions* were edited and distributed to the Research Project Advisory Committee for final revisions. Questions were organized into categories to assist potential researchers identify topics of interest.

The conference attendees included rural, science, mathematics, and technology educators from across the country representing universities, public schools, and Rural Systemic Initiatives.

Identifying the Next Steps

During the conference discussions, the participants generated a large number of questions in which there is a dearth of literature and which they considered "worth researching" about understanding achievement in science and mathematics in rural schools. In many cases, these same questions should be asked regarding other settings as, for many of these issues, the answers are probably not different for rural areas as compared to anywhere else. The consensus of the participants was, however, that we really do not know if the research conducted in urban and suburban districts applies in rural districts because the research into teaching and learning of mathematics and science and rural schools is extremely limited and generally not readily available. ***The conference, and this publication, is an attempt to articulate questions about science and mathematics instruction in rural settings, which can then be the basis for future research projects.***

Questions that emerged during the discussions of the conference participants were grouped into seven categories: Community Support, Instructional Resources, Leadership and School Reform, Professional Development, Pre-service and Induction, Curriculum and Instruction, and Database. Listed within each category are groups of selected questions that were generated for each specific topic. Clearly, these lists are not exhaustive but are intended to stimulate discussion and research among the science and mathematics academic community. The conference, and the resultant publication, is merely a "departure point" from which it is hoped a significant research effort will be initiated, resulting in a new body of literature related to science and mathematics education.

Other *themes* emerged that became a part of the discussion of the questions as well. One major theme was that research on the rural experiences of mathematics and science education should not be restricted to the rural circumstance only, but it should be compared to suburban and urban mathematics and science education experiences. Another theme was that rural settings differ greatly from each other. Rural in different parts of the country is very different, e.g., rural Iowa, the delta South, Native American reservations, rural Appalachia, etc. Even within a rural county the circumstances in the major population area may be very different from the experiences in the more remote areas of the county. Consequently, cross-site studies in rural areas could provide interesting differences, especially in terms of the implementation of new curricula for mathematics and science. A third theme emerged about gender equity, i.e. are there differences in mathematics and science education that have gender differences as their basis particularly as compared to their suburban and urban counterparts. Finally, a fourth theme emerged, the use of technology. Even though rural areas can be remote, technologies of all kinds, from networked computers to satellite course delivery and many other ordinary and unique uses, have connected rural areas to the entire world. The teaching and learning potential, as well as impact, is largely still unknown.

An unanticipated, but important, outcome of the conference was the identification of a set of "difficulties and concerns" regarding the status of current research in rural settings. One recommendation emerging from the conference was that a study, that synthesizes the research that has been done on rural settings, be completed with the intent to give researchers a "baseline" for new studies. This would be a large undertaking because rural school data are often "hidden" in larger studies as rural schools may simply be one or more of the sites for a multi-site study.

Another concern discussed at the conference related to "research methodology" as many of the questions identified by the participants are suitable for different types of studies and research methodologies. Some questions, for example, may be more appropriately approached using qualitative studies, while others are better answered by quantitative methodologies.

A final concern was the *usability of the research* outcomes by the people who live in rural areas. Education research, in general, is underutilized and Hobart Harmon (refer to this volume) states that *"Rural culture (is) historically not responsive to abstract scholarship."* Therefore, an important question emerging from these concerns is "how to translate research findings into usable information that can be used by rural educators and their communities to change science and mathematics education into more effective ways of teaching and learning."

Community Support

The "community school" is the primary focus of rural education. Rural schools may be the last bastion of the traditional community and the only place that brings the entire community together regardless of age or economic status. This category, of researchable questions, would guide research regarding how mathematics and science instruction is perceived in rural communities and how this instruction is supported. For example, the perception of many educators and community members is that mathematics and science instruction is not well supported. Also, are community perceptions and support for science and mathematics instruction uniform across rural settings? The research on these issues is minimal or nonexistent. Well designed and relevant research should provide answers to these questions.

1. What do schools and districts need to know about rural communities in order to provide relevant science and mathematics learning?
2. How do parents and community members in rural areas define *quality* science and mathematics education as compared to urban and suburban parents and community members? Does this perception vary from the perceptions of students, teachers, and administrators in each environment?
3. What mathematics, science, and technology skills are perceived as needed by people in rural communities?
4. Do science and mathematics knowledge and skills used in rural communities differ from those used in urban and suburban areas?
5. What are successful ways that schools have involved rural communities in science and mathematics curriculum development, teaching, and learning?
6. What are the implications of information technology in rural areas with respect to mathematics and science learning?
7. How do rural community attitudes about science and mathematics impact instruction and student achievement?

Instructional Resources

Having adequate resources is an issue in all schools, but instructional resources in rural schools are most often *the* critical issue for the delivery of quality mathematics and science instruction. With the advent of the computer and associated information technologies, the issue of resources has become even more acute in most rural areas, but also perhaps, holds the most promise for increasing learning opportunities. The following are a number of *key questions* concerning instructional resources for rural settings. Generally, these questions address "How can the disadvantages of remoteness, cost, lack of infrastructure, and lack of access be addressed?

1. What are the accessibility, availability, use, and effectiveness of advanced digital technology to teach mathematics and science in rural schools?
2. Does the selection, purchase, and implementation of instructional materials, textbooks, and instructional technologies differ in rural schools as compared to other schools?
3. How does the school's setting impact the *cost per graduate* of advanced mathematics and science instruction in rural schools compared to schools in other settings?
4. How can the teaching and learning of science and mathematics in rural schools be improved through the effective integration of technology?
5. Can the effective use of technology for mathematics and science instruction in rural settings be replicated? What are the indicators of the successful use of this technology?
6. Are there differences or inequities in student opportunities to use instructional technology for mathematics and science instruction due to racial, gender, or socioeconomic status in rural settings.

Leadership and School Reform

The improvement of science and mathematics instruction in any setting is dependent upon leadership and the pressures for school reform. Leadership in the reform of mathematics and science curricula in rural settings is problematic in terms knowledgeable leaders and the understanding of mathematics and science reform movements in general. Obtaining and/or developing this leadership, in regard to both initiating and sustaining reform in science and mathematics education are key issues. Other issues are how to maintain and support this leadership for reform. It is clear, in all settings, that *lasting reform* takes time to develop. Research on these leadership issues should not be limited to rural settings, however, it is clear that the following questions need to be answered for those working in a rural circumstance.

1. To what extent do leadership expectations, levels of support, and encouragement impact teachers' use of innovative strategies in mathematics and science in rural schools compared with other settings?
2. What are the factors and experiences that contribute to teachers emerging as leaders for science and mathematics program reform in rural school environments?
3. What experiences prepare teachers to serve as leaders in the role of change agent for the improvement of science and mathematics education?
4. How can technology be used to develop leaders for science and mathematics education reform in rural school environments?

5. What leadership activities encourage the integration of technology into science and mathematics classrooms in rural schools?

6. What are the unique situations that promote a culture for innovative practices in mathematics and science programs in rural school settings? Are these strategies different in other school environments?

7. What strategies are most effective for developing successful science and mathematics programs in rural school settings? Are these strategies different in other school environments?

8. What are the relationships of mathematics and science standards, content frameworks, and assessment to successful implementation of standards-based mathematics and science in rural settings?

Professional Development

There are many issues that impact how the needs for the professional development of mathematics and science teachers are determined and subsequently, how the needed professional development is delivered. Teachers of mathematics and science in rural schools predominantly fall in one of two camps. In many situations, those who teach mathematics and/or science are teaching out-of-field or in a secondary teaching area. In these cases, teachers are generally not well prepared to teach mathematics or science and often need basic content knowledge. In many other situations, the mathematics and/or science teachers have appropriate certification and sufficient college coursework, however, their preparation is "outdated" and there is a need for training in both current content and pedagogy. Both "getting up to speed" and "keeping up to speed," with the changes that are taking place in both the content and teaching strategies, has been especially difficult for rural teachers as appropriate in-service opportunities for mathematics and science teachers are often unavailable in rural areas. The researchable questions for "professional development" tend to focus on the characteristics of teachers and the teaching environment in rural school settings.

1. What is the relationship of teacher qualifications and characteristics to student learning of mathematics and science in rural areas as compared to other areas?

2. Are there characteristics of rural mathematics and science teachers that influence their perception and use of instructional technologies?

3. How do the resources which rural science and mathematics teachers utilize when they need help differ from the resources used by teachers in other settings?

4. What are the characteristics of highly competent mathematics, science, and technology teachers that predict persistence in a teaching career in rural school settings?

5. How do career paths of advanced mathematics and science teachers in rural schools differ from other schools and other rural settings?

6. What type of professional development is effective in improving and enhancing the science and mathematics content knowledge of teachers in rural areas?

7. What policies, state and local, encourage rural mathematics and science teachers to continue their content training beyond their initial licensure program?

Pre-Service and Induction

Teacher education and alternative licensure programs are the routes into the teaching profession. The common wisdom has it that very few, if any, of these programs focus on preparing teachers to teach in rural areas. Although many of the teacher education and alternative licensure programs do place candidates in rural schools for their extended field experiences, there is little evidence that pre-service programs incorporate specific experiences related to teaching in such schools. Knowledge related to recruitment, academic program quality, and specific activities which result in skilled mathematics and science teachers who enter rural classrooms and *stay in rural classrooms* is the basis for research in this area.

1. What are the characteristics of successful teacher education programs which are specifically designed to prepare mathematics and science teachers for teaching in rural schools?

2. What activities conducted by colleges assist student majoring in mathematics and science or preparing to become mathematics and science teachers successfully transition into higher education?

3. What motivates people to become science or mathematics teachers in rural districts in contrast to other settings?

4. What strategies are successful in recruiting and retaining science and mathematics teachers for rural schools? Are these strategies similar or different from other types used by other districts?

5. What factors prevent or encourage first year science and mathematics teachers in rural areas from utilizing their university learned skills in their classroom practice as compared with teachers in other settings?

6. What are effective uses of virtual learning and technology in preparing and supporting mathematics and science teachers for assignments in rural communities?

7. What factors encourage females and males from rural areas to pursue degrees in mathematics, science, and technology in higher education?

8. What activities conducted by colleges enable rural students majoring in mathematics and science successfully transition into higher education?

Curriculum and Instruction

When all the pieces are in place, the resources, the teachers, and the students, what is taught, how it is taught, and the resultant student learning are of primary concern. The curriculum becomes the tool for identifying what is taught and how it is assessed. The delivery of this curriculum, through a myriad of instructional strategies and styles, is key to student learning and in large part, determines whether students become knowledgeable about mathematics and science or not. In addition to the basic research into student learning, there is much to learn about what increases student learning of mathematics and science in rural schools and whether this is different from student learning in other contexts.

1. How are mathematics and science education *standards* translated into curricula and instruction in rural schools in comparison to other settings?

2. How do the science and mathematics curricula that are taught differ from textbook curricula and district curricular guidelines in rural settings in comparison to other settings? How does this differ for advanced courses across settings?

3. Is informal education in science and mathematics more influential in rural settings than in other settings?

4. How can teachers in rural settings make mathematics and science more relevant to real life contexts?

5. How do traditional gender roles impact mathematics and science achievement in rural school settings? Do traditional rural gender roles impact the courses chosen in science and mathematics?

6. What instructional strategies result in higher student achievement in mathematics and science in rural schools? Are similar results obtained in other settings?

7. How do science and mathematics assessment strategies used by rural teachers differ from those teachers utilize in non-rural settings?

Data Base

There is a great deal of information about rural settings that is part of federal, state, and local databases. This important information could be used for the improvement of mathematics and science instruction, but it is generally not pulled together in usable formats. Identification of the appropriate databases and access to them could provide valuable information that previously has been unavailable. While such information does not provide a complete picture of rural settings, it should provide additional information about the state of mathematics and science instruction in these areas.

School profiles would be helpful as background information for the study of science and mathematics education in rural settings. Such profiles should include: how long teachers have been teaching; how long principals have held their positions, the student dropout rate, the teacher retention rate; school sizes in rural environments; class sizes; and other information which would round out the profile. Rural *community* profiles would, also, be helpful as background information and might include: assets mapping (businesses, organizations, services, etc.), community views of innovation, communication issues, ethnicity, and demographic variables that might impact mathematics and science instruction.

Research guided by the following questions would contribute to the general knowledge base of teaching and learning science and mathematics in rural schools.

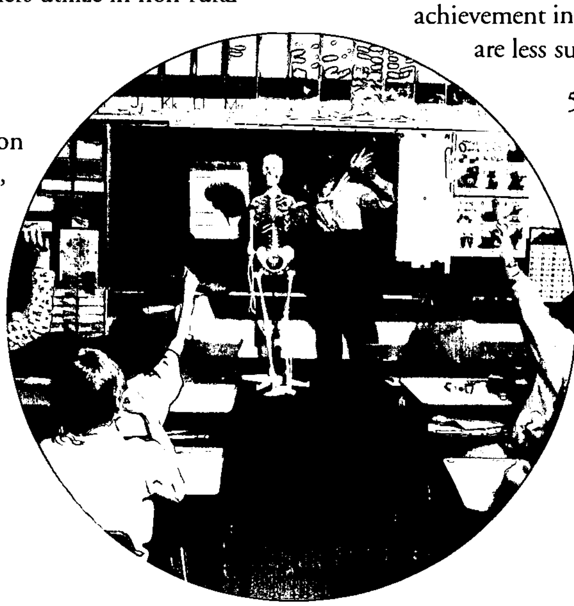
1. What are the socioeconomic issues related to instruction and student achievement in mathematics and science education in rural settings as compared to urban and suburban areas? Do these same socioeconomic patterns reoccur in advanced mathematics and science courses?

2. How is success in mathematics and science defined in rural areas compared to other areas? How do parents, students, the community, the state, and the nation define success in mathematics and science?

3. How do capacity issues such as leadership, teacher turnover, instructional resources, etc., influence success of students in science and mathematics classes in rural settings?

4. What factors distinguish schools in rural areas that have high achievement in mathematics and science from those that are less successful?

5. What factors contribute to out-of-field teaching in science and mathematics in rural settings? Are these factors different in other settings?



Understanding the Circumstances of Rural Schooling: The Parameters of Respectful Research

This paper presents my view of the foundations on which to research rural schooling. I'm interested in rural schooling in mathematics and science partly because I do a form of science enabled by statistics, most of it focused on dilemmas in rural schools and communities. I'm looking forward to doing more of this work and helping others do it too.

I was asked to cover the "parameters" of rural education research. Please note that I'm not going to tell you precisely *what* to study, but more like how to study it. However, this task means helping you to see the connections between *what* and *how*. This isn't easy work, considering the challenges outlined below:

Objectively speaking, rural education is important to American schooling because Local Education Agencies are the main actors in educational governance, and rural and small-town *school districts* comprise an astounding 63.8 percent of all public school districts in the U.S, and about 20 percent of these districts are located within *metropolitan* counties. The rural setting is therefore far more common than most of us realize.

And yet, very few scholars devote any attention to rural education. Alan DeYoung, from the University of Kentucky, is the leading rural education scholar, and he went to Stanford for his doctorate. Jonathan Sher was previously the leading rural education scholar and he went to Harvard. Unfortunately, the habit of looking to Stanford and Harvard for world-class scholarly leadership in rural education research is actually part of the rural problem for *us*. We don't need world-class leadership as much as more locally grounded leadership.

Many institutions with reputations less bright than those of the elite schools would gladly sell out their host communities in rural areas in order to lay their hands on a fraction of the soft money that flows so easily downhill to places like Stanford and Harvard. Higher education institutions have global reputations to build or maintain and they don't really want to be *seen* with their hick neighbors, much less *working* with them.

There *are* individual exceptions, however, even in the natural sciences.

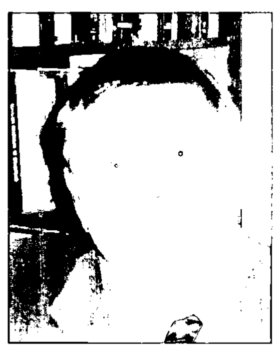
Nick, for instance, is a physics professor at the University of Wisconsin. Nick has been interviewed, together with a dozen other people, every seven years since he was seven years old for Michael Apted's famous "Up" series. The series began in 1958 with 7-Up and has recently concluded with 42-Up.

The latest interview was conducted when Nick visited the old homeplace in his rural community. The off-camera interviewers asks Nick, "It's incredible that it all started here, isn't it?" Nick, is quietly annoyed, and he replies,

"Yes and no — you shouldn't underestimate what resources people have. You shouldn't look at this little place and say, "How surprising that anything could emerge from here." I mean, these are fantastic people and you don't get better teachers anywhere else than we had. So, no, it is not surprising." (Singer, 1998, p. 89)

Nick went to Oxford University — more elite even than Harvard — for his undergraduate and graduate degrees. And he's saying he *had no better teachers*, by which he also means the neighbors from whom he learned how to live, than in his little podunk of a home place. At the beginning, my best counsel is that we try fully to understand what Nick is saying. His statement applies to *us and the work we have to do.* On to the main points.

Craig Howley



Craig Howley has researched rural education and published his findings widely. He has taught mathematics at the University of Charleston and has evaluated math and science projects in the rural schools. He is co-editor (with Hobart Harmon) of Small High Schools That Flourish (AEL, 2000) and co-author of a well-received monograph titled *Out of Our Minds: Anti-intellectualism in American Schooling* (TC Press, 1995). Dr. Howley is director of the ERIC Clearinghouse on Rural Education and Small Schools and Adjunct Professor in the Educational Studies Department at Ohio University.

Think of each of the three main parts of this paper each as a different parameter of rural education research into mathematics and science education. The three parts deal with (1) research method, (2) content, and (3) the application of research. I advise a *conservative* approach to method, a *liberal* approach to content, and a *radical* approach to application. Let's begin, then, with a consideration of method.

Method

If you really get into research, you'll soon enough give up the simple word "method" and start using the word "methodology" instead. It's a word that means "method" but has the added advantage of scaring audiences. That feature is very handy if your audiences are graduate students who need to take this stuff seriously, but can hardly believe it's necessary to *have* a stance toward reality, or to question the *existence* of reality, or to decide *how to study it* whether it "really" exists or not. They think you're kidding them when you talk this way. By the time they get to the dissertation they're no longer laughing.

My *conservative* perspective on method is really quite simple. Reality exists. We can know many of its features by devoting sufficient care and attention to our investigations. A more liberal position says that reality is debatable, but that we can sort of intuit it. A radical position would insist that social reality is created almost entirely by ideology and that in order to know reality, what you really have to know is ideology.

I believe that the radical version is true, and that it's a fine grounding for political critique. But it's much less useful for designing research that you expect anyone but academics or literati to heed. This means I don't advise critical theory or postmodernism as a research paradigm for this work. Now for a bit of background.

We've subjected our doctoral students at OU to Lincoln and Denzin's tome on qualitative methods, and maybe you're familiar with their four-part scheme describing research perspectives. The four parts are something like *positivist, post-positivist, critical theorist,* and *constructivist* (really meaning postmodernist). That's it! All you need to know to pigeon-hole every pinhead on the planet! It's very handy for graduate students, but a little too simple for reality.

The basic ideas behind the four perspectives are simple. Is there really something solid "out there" to study? Or do words constitute reality, so that reality is really the way words (and other symbols) are used? Positivism and post-positivism shade toward the former position — the existence of a solid reality — and critical theory and postmodern-style constructivism toward the latter-reality as a sort of text. Positivism and post-positivism are more conservative, whereas critical theory and "constructivism" are considered more intellectually radical. Whether they are politically more radical is a topic of ongoing debate.

I advise a *post-positivist* approach to rural education research. Why not any of the others? Positivism is too deterministic for the social sciences. Critical theory and constructivism, on the other hand, are twentieth century innovations specifically in the social sciences, which means you can use them to understand the history and politics of science, but applying them to the study of the material reality of natural science would strike even some of their proponents as a misdirection.

I believe we ought to treat rural context as structurally conditioned and therefore presenting a material reality. By structure, of course, I'm referring to *very durable* features of economics, politics, history, and culture that fashion the circumstances that we somehow so solidly encounter as "rural." The structures constitute, or condition, or guarantee a material reality that is *available* for us to study.

Now, this insight about the wisdom of studying the influence of durable structures in the rural circumstance means that "rural" is *not* reducible to a geographic category, nor to a residual category of "urbanized place."

The rural circumstance is *not* about *residence*, just as being a person of *color* is not about *color*. The rural circumstance is much more than residence, and that's what so many people apparently cannot fathom. Most of what rural people do and are is invisible from the cosmopolitan perspective of university research and multinational business. And that is precisely why it's incumbent on rural education research, in designing its studies, to grapple intellectually with the material structures of economics, politics, history, and culture that condition the rural circumstance. The education of individuals is profoundly shaped by these structures, and these structures shape even more profoundly the institutions and technologies of schooling, into which contemporary society tries desperately, and unsuccessfully, to pour so much of the process of education.

Coming to know mathematics and science in rural schools and communities, then, is nested within all these structures, not just for us, but also for students. The structures inevitably shape the *engagements* of learning and teaching as well as the *evasions* of learning and teaching that transpire in rural schools and communities. This is a complex reality. Please note what this complexity indicates. It indicates that, from the vantage of living and loving in rural places, we'd probably find that some of the *engagements* make *bad* sense and that some of the *evasions* make *good* sense. Some of what we must find will be counterintuitive; if it's not, we're not doing research.

The rural circumstance exists. You can see it, touch it, live in it and live from it quite well, though with difficulty. The ways it looks, feels, nourishes, and challenges one arise from centuries of social relations so durable as to be largely habitual and predictable. Rural is not *willfully* shaped by discourse or superficial changes in discourse. Rural is there, it's real, and we can study it rather objectively. To frame our questions, however, we critically need to reflect on rural economics, history, politics, and culture.

While we cannot very well establish *laws* relating the various features of schooling and the rural circumstance, as we would try to do in the positivist perspective, we can, in the post-positivist perspective, actually establish tantalizing relationships among contexts, processes, and outcomes. By adopting a post-positivist stance, as well, we can establish these relationships using methods that are wide accepted and understandable. This means there's a chance our findings will get a hearing.

This conclusion about method is a *terrible* irony, because it means that we adopt a materialist, post-positivist perspective on reality in part because the discourse it uses to interrogate reality and to report its findings is more *comprehensible* to a wide audience than would be the products of any of the alternatives.

Content

Recall that the foregoing remarks advocate a conservative stance toward method. Here I'm advocating a *liberal* approach toward content. I'm not modeling my use of these terms after partisan politics. In this instance, by "conservative" I mean to suggest a degree of narrowness with respect to method and by liberalism I simply mean to indicate a more circumspect, and less narrow, view of content. There's a light side of this issue and a dark side.

On the one hand, a conservative view of content would take the position that research about mathematics and science education in the rural context is about mathematics and science education. That's narrow and it sounds quite sensible and is certainly the way most research into the topic *has* actually been done.

The problem is that this position assumes that we really know what best practice looks like and that it's the same everywhere. The clear task is how to get more of it actually happening, and so context principally presents the challenge of how to tweak best practice so that more of it can happen in particular places-for instance, in Adams County, Ohio, or MacDowell County, West Virginia, or in the Philadelphia or DC Public Schools.

Conversely, a more liberal view of mathematics and science education in the rural context accepts the well-known fact that context actively influences educational purposes, processes, and meanings. But more importantly, it will focus not on mathematics and science curriculum and instruction per say, but more on their *interactions* with context. It's a somewhat "constructivist" view, not of instruction so much, but of the lived experience of being in rural schools and communities. A fair minority of mathematics and science educators, if the recent AERA program is a good indicator, have engaged this idea of social constructivism in science education. And in fact, the old SST curriculum—science, society, and technology—embraced the challenge of context decades ago, not in reality, of course, but as a definitive part of the science curriculum.

Now with respect to the light side of the issue of content, one's stance is seen as contingent on a technical point having to do with perceptions of the role of context in reality. Is context pretty tangential to the real work of schooling, or is it quite influential and therefore worthy of *considerable* attention? If you believe that the real work of schooling has to do with things like instructional design and curricular scope and sequence, you'll likely embrace a more conservative — or, a narrower —stance. If you believe the real work of schooling has to do with the cultivation of intellect in all its powers — ethical, political, historical, and cultural — you'll doubtless take a more liberal, or broader — turn. This sort of liberality is the sort of liberality represented by the liberal arts, and it's germane to the fact that the home of mathematics and science in universities is typically in colleges of liberal arts.

To clarify this position, the price of doing research that focuses on *rural context* is that you carry through with that focus, and that carry-through *requires attention to the interaction of the context of schooling with the content of schooling.* I'm saying further that schooling cannot constitute a decent education absent context. A lot of who we become is our families and communities and those we love. You can drop out of school, but you can't drop out of education.

Now for the dark side of this issue of content. The lighter version of the conservative position comes with an embedded, but quite hidden, view of rural that is the kiss of death to studying the rural context. That *inscribed*, but often tacit view, is that the rural context is *fundamentally deficient.* Jim Goad in *The Redneck Manifesto* points out correctly that rural people are the only group to have escaped the injunctions against bigotry.

Country people can be mocked as ignorant and clownish with impunity any time. I saw it happen to Paul Houston at the American Association of School Administrators annual meeting a couple of years ago. Paul is the executive director of AASA and he comes from West Virginia. As he mentioned his roots, a member of the audience piped up, "We all have our crosses to bear." The rest of the audience laughed. We hissed loudly.

The realization that he was confronting exactly this deficit view is what Dr. Nick, our physicist, was bridling against in the interviewer's question. He surely continues to have this deficit view inflicted on him in much the same way Paul Houston does. But in their experiences, and in mine as well, rural people are just as obviously worthy, maybe among the most worthy on the planet. They get that way not through schooling, but through tough times, courage, love, and, most importantly, unrecognized *intellectual application.* Surely, Nick was saying, these qualities are the foundation of a true education! It's priceless and it's not for sale anywhere. If schools and communities are not pretty closely in tune, both schooling and education suffer. They *are* suffering. This makes the work we need to do quite practical.

This hidden curriculum of the conservative stance toward content is the principal *negative* reason I advise a more *liberal* stance toward content. The principal *positive* reason I advise a liberal stance is that it's logically consistent with a rural focus. If you don't respect something, you shouldn't study it. Far from harboring a bias, a respectful stance *actively constitutes objectivity*. The deficit view is a hidden bias that's fatal to the object of study.

Application

My stance on application is radical. The radical approach is to insist on seeing an issue with its roots dangling in full view. Therefore, a conservative method has a narrow focus, a liberal content has scope, and a radical *application* has roots.

Let's begin with a repudiation of the conservative view of the applicability of research. Note that I'm not saying the conservative approach is wrong, misguided, or unworthy. It is, however, inapt to our proper purposes, which are to respect and understand the rural circumstance in hopes of improving mathematics and science education in and, critically, *for* rural communities. This hope is our motive for being involved with application at all. It makes application *necessary*.

The traditional, conservative, narrow view of application, which I learned in high school, rests entirely with advancing the consideration of interesting intellectual problems and not very immediately with the problems of the real world. We've pretty much abandoned this view of natural science, much to my chagrin. My teacher, Artie Lehrhaupt, tried to cultivate in his students the *high* and *noble* purposes of science, the serene beauty of contemplation, and the wonder of natural laws lurking unseen in reality. It was very convincing, and Artie helped me see the connection between philosophy, music, mathematics, and science, and he encouraged us to read; I'm still grateful for his gift. It's served me very well.

In the conservative view, applications are the concern of technologists, not of scientists. That's the view I learned in high school, but to educational researchers, this view sounds like wasteful luxury. There is much to admire in the conservative view. In particular, the conservative perspective acknowledges a key truth that liberally-minded educationists don't. The conservative perspective understands that *desperation* to apply research findings, or desperation to conduct research for practical reasons, is bound to be *thoughtless*. Scientists learned this lesson in developing the nuclear bomb, and they've written extensively about their insights. Desperate times drove them desperately on, and they've given humankind an evil legacy. The bomb is there and it will *inevitably* and *unavoidably* be used again, sometime. History is long and we forget that.

There is way too much desperation in the application of the findings of educational research, and the desperation increases precisely because so many people clamor for educational research that is *truly and immediately practical*. The longing for research that is truly practical is desperation that is masquerading as common sense. And it's welcomed as common sense, and in this disguise does great mischief as will be explained shortly. So I do think a conservative approach to application has something to offer; it's remove from the real world, however, means that it just doesn't comprehend enough of the story to guide us, once we've adopted a respectful attitude toward the rural life world.

In the liberal view, by contrast with the conservative view, there is not really any such thing as educational research since nothing like *basic research* is possible in a field like education. What we have in education is *applied* research, and I know this is true because Gene Glass says so. Gene Glass is mathematically brilliant, author of the most comprehensive and best-selling text in statistics for educational research, and inventor of meta-analysis, but he claims he's wised up and is no longer "a quantoid." A quantoid, if you don't know, is a positivist with a very simplistic view of what's real. If you can count it, say the quantoids, it must be the truth. Glass's view of application has become quite sophisticated, and he seems to believe that application is a conversation with reality. His is a radical, not a liberal view. You'll recognize elements of critical theory and the postmodern in it, though I doubt Gene Glass is either a critical theorist or a postmodern.

I agree with his stance on application. What else could application be *but* a conversation with reality? I'm getting ahead of myself, however, and want to explain the liberal perspective a bit more.

Like Dr. Glass, the liberal perspective does not view any educational research as "basic." If you have doubts about this, ask yourself what basic research problems education as a pure discipline would be asking that sociology, psychology, and political science aren't already asking. Those would be the questions that history, philosophy, literature, and religion would be asking. In the liberal view, research should be more like evaluation, and this seems to me the prevailing view with respect to application.

The problem of what works (see Glass, 1987), looms large in our field and we have dreadful difficulties talking about it since most of us were classroom teachers who, at one time, were very, very sure that some of what we did "worked" and some didn't. We think the same sensibility must apply to the educational system and to educational programs as a whole. Everyone is rushing, and rushing desperately if you ask me, to find out what works and then, even more desperately rushing to make "what works" work.

In the liberal mode, we want to put *research* to work telling us what works. In its most debased form, then, the liberal view turns *every* research project into an *evaluation* project. Each year that I attend AERA, more of what is talked under the rubric of research is very ordinary evaluation.

So what? It's just that, alas, evaluation *also* has trouble telling practitioners the truth about what works. This is so because in all efforts to show the validity of reform programs or products, the overall positive effect sizes given in evaluation reports mask substantial variability. Yes, on average, there are benefits, but, no, in many schools the achievement benefits not only don't materialize, but achievement deteriorates and doesn't bound back to higher levels. For instance, in two-fifths of the cases, statistically significant improvements materialize; but in only half of those cases are the statistically significant improvements are significant in practical terms, as well; in two-fifths of the cases, no statistically significant improvements are noted and the fine print won't tell you that in one-fifth of cases, things get worse at statistically significant levels, and in half of these cases the damage done is significant in practical terms.

In essence, you have a validated program that does real good in 20% of sites and real damage in 10% of sites. In actual programs, of course, the proportions of good and evil vary, but the pattern of uneven success is constant.

It's always a question of odds rather than certainty. Just because the odds are better than even doesn't necessarily make us all winners. And we shouldn't mistake better-than-even odds for an underlying certainty of universal good that would materialize if we just got rid of the human beings who mess things up (Mintzberg, 1998). *Our special burden in education is human beings who always mess things up.* We're only human, especially as social science researchers.

Do we really want to do more of this sort of "research" just in order to determine if Math Program X is generally better in rural schools as compared to Math Program Y? In the end, you know, we'll be stuck with exactly the same problem. The rurally validated program will be a bad fit in *some* rural places. And the rurally unvalidated program will be a good fit in *some other* rural places. We probably need to do some of this work from the vantage of rural competence rather than rural deficit, but this work should be of second or third rank.

Far from being wild-eyed, what I'm calling the radical view has a more sober view of reality than the other views. The conservative view says that reality doesn't matter all that much. The liberal view says that research should improve reality without knowing what reality is. The radical view says that reality is complex and application will always be compromised and ambiguous. The radical view is also honest about what works: nothing works in the sense of working everywhere. Large sums are spent developing and validating good programs. They need to work, therefore, but the actual workers *are only human.*

This outlook is heresy, but the radical view does something even more heretical. It says that, given the limited practical benefit of validating programs, we need to be very suspicious of our notions of "what works." Works for whom? Damages whom? [illegible] does it work to do? Is this good work? Why and why not? What is required? Who says so? In the radical view, these are not questions for experts because it's most important for ordinary people to ask and answer such questions. Indeed, cultivating that ability is the work of education. Schooling could help.

A radical perspective on application appreciates the fact that research results enter a conversation about how ordinary people would like reality to be. What research needs for this work, but too often lacks, and which evaluation is by definition *designed to avoid,* is an edgy critical outlook on reality. And please note that in dealing with content of *difference from the mainstream* (as in studies of the African American circumstance or the rural circumstance), this critical edginess is what animates the research project at the outset and enables its application in the end. That's why a respectful view of content is critical.

Conclusion

One wants to conduct research that will make a difference. So one chooses a method that is comprehensible and accessible to a wide audience, and one should choose conservatively for this reason. Second, one must approach the rural context liberally, meaning respectfully, simply in order to allow oneself to see clearly the object of investigation. But third, one wants to design research that is provocative, that *intends* critical responses in the public domain, but without giving the researcher the special authorial voice of all-knowing expert.

The funny thing is, the more practical we try to make it, the less practical educational research becomes, since our obsession with practicality makes us continually more desperate and less thoughtful. When this is our approach, we're really helping to disseminate what doesn't work, and doing it in a way that magnifies the problem. It's like purposely designing feedback loops that create increasing disorder. Jay Forrester (2001), one of the grandfathers of dynamic systems theory in the natural sciences, thinks this is exactly what the educational accountability movement is doing. It's making things worse, he claims, through feedback loops that magnify dysfunction.

I do want to end with a few contrasts to suggest what applying this counsel might look like. I'm trying to be practical rather than desperate, and it's a fine line to tread.

1. Instead of asking, "What features of rural schools encourage successful use of world-class curriculum in elementary mathematics instruction?" ask

   "What interactions between rural schools and communities make the boundary more permeable between school mathematics and mathematics in the rural life world?"

2. Instead of asking, "How can we overcome rural parents' disinterest in mathematics education?" ask

   "What do rural parents expect in mathematics curriculum and what does it mean that they hold such expectations?"

3. Instead of asking, "Why do some rural districts prefer Saxon Math to Connected Math?" ask,

"What connections to or influences from local rural communities or circumstances distinguish effective rural mathematics classrooms from ineffective ones?"

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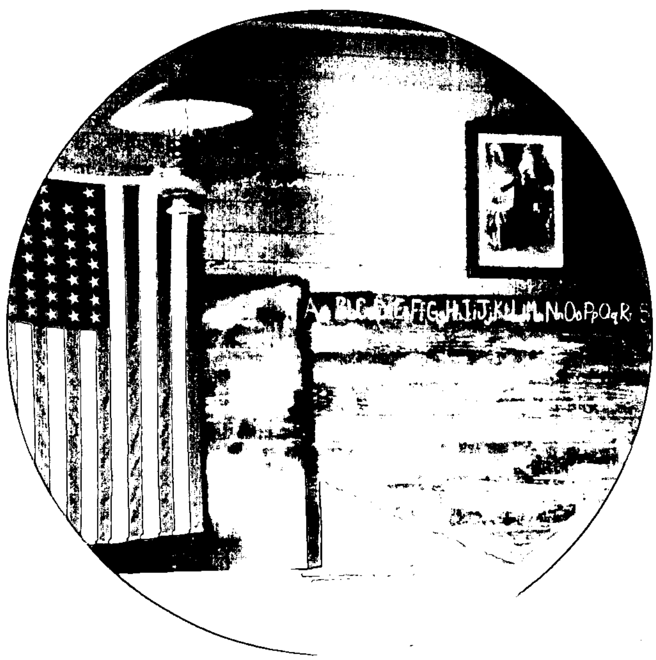

Education Issues

Education Issues in Rural Schools of America

The rural segment of American schooling is significant. In 1997-98, almost two-thirds of the more than 14,000 school districts, including some "urban" school districts with rural schools, could be considered rural (Howley, 2000). More than 45 percent of the nation's public schools are located in rural areas and small towns (Harmon, 1997; McLaughlin, et al, 1997). Almost 40 percent of the nation's public school teachers work in these rural schools (National Education Association, 1998). More than coincidently, the success or failure of these schools–including the work of well-meaning education researchers and reformers–depends greatly on understanding issues critical to schooling in rural America.

Most assuredly, how one values rural America can greatly influence how one perceives, interprets, acts on, or researches an educational issue. Craig Howley's (2001) keynote address at this conference highlights the need to conduct research in context with the rural circumstance. This paper briefly describes some key education issues that researchers and reformers are likely to encounter in many rural communities at the dawn of the new millennium.

Valuing Rural America

Rural America has been and continues to be a vital part of the Nation. Today, rural America comprises 2,288 counties. It contains 83 percent of the Nation's land and is home to 21 percent (51 million) of its people (United States Department of Agriculture, 1995). The United States, like the rest of the world, is steadily becoming more urban. The 1990 Census reveals not only that the majority (52%) of Americans live in urban areas, but also that for the first time in our history they live in areas of one million or more people.

Why do people value rural areas? In the spring of 1995, scholars from a wide range of social science and humanities disciplines met to discuss the "value of rural America." Rowley (1996), writing the introduction to articles prepared from the meeting for a special issue of *Rural Development Perspectives,* notes that both pro-rural and anti-urban values are persistent and powerful in American myth, reality, and political and social discourse:

> For many people, rurality connotes intrinsic value. That value can be positive, as expressed by such rural descriptions as pastoral, bucolic, and untamed. It can be negative, as in desolate, backward, and isolated. These values have developed throughout the nation's history and are expressed in its literature, art, music, popular culture, political opinion, and residential preferences.

Furthermore, Americans value rurality for what it is, what it is not, and what they believe it is or is not. (p.3)

Rural America has changed in many ways. Today, the rural economy in particular has changed-shifting from a dependence on farming, forestry, and mining to a striking diversity of economic activity. Improvements in communication and transportation have reduced rural isolation and removed many of the cultural differences between urban and rural. Television, phone service, and transportation systems have helped bring rural and urban dwellers much closer together in terms of culture, information, and lifestyles. And while it continues to provide most of the Nation's food and fiber, rural America has taken on additional roles, providing labor for industry, land for urban and suburban expansion, sites for storage of waste and hazardous activities, and natural settings for recreation and enjoyment.

Hobart Harmon

Hobart Harmon is a private consultant with much experience in rural education. For almost seven years, he was a senior research and development specialist for AEL, Inc., one of the 10 federally funded Regional Educational laboratories in the U.S. While there, he directed the national Rural Education Specialty, The rural Center, and the ERIC Clearinghouse on Rural Education and Small Schools. He was also an Executive Assistant to the West Virginia State Superintendent of Schools. In addition to co-authoring a textbook, Dr. Harmon has authored or co-authored more than 25 articles and technical reports and authored the rural education section of the *Encyclopedia of Education* (2nd edition, 2002).

In the book, *Rural Education: In Search of A Better Way,* Nachtigal (1982) maintains the important factors that differentiate a rural community in one part of the country from a community of similar size and isolation in another part of the country appear to be related to (1) the availability of economic resources, (2) cultural priorities of the local community, (3) commonality of purpose, and (4) political efficacy. Nachtigal describes some basic differences between rural and urban areas:

Rural

Personal/tightly linked Generalists Homogeneous
Nonbureaucratic
Verbal communication
Who said it
Time measured by seasons of year
Traditional values
Entrepreneur
Made do/respond to environment
Self-sufficiency
Poorer (spendable income)
Less formal education
Smaller/less density

Urban

Impersonal/loosely coupled
Specialists
Heterogeneous
Bureaucratic
Written memos
What's said
Time measured by time clock
Liberal values
Corporate labor force
Rational planning to control environment
Leave problem solving to experts
Richer (spendable income)
More formal education
Larger/greater density

These characteristics are reflective of the rural context. They help give meaning to researchers and reformers who sincerely seek to improve the performance of rural schools in general, and student achievement in particular. Moreover, perceptions of all rural schools as inferior schools are incorrect. States with a predominance of small, community-centered schools do rather well. For example, on achieving the National Education Goals, in 1998 eight of the top ten states on math and science performance, six of the top seven on student achievement in the core subjects, and all top five on parent involvement were rural states (Lewis, 1998).

In fact, many of education's so-called "innovations" today were born out of necessity long ago in the rural school (Stern, 1994). Examples include cooperative learning, multi-grade classrooms, intimate links between school and community, [i]nterdisciplinary studies, peer tutoring, block scheduling, the community as the focus of study, older students teaching younger ones, site-based management, and close relationships between teachers and students. With each passing generation, however, fewer Americans, including educators, understand the significance of rural areas as places of innovation-rather, deprivation and despair characterize the perceived rural circumstance for a growing population of "urban" dwellers in a global economy.

It is tempting to generalize and oversimplify, to characterize rural areas as they once were or as they are now in only some places. Still, there is an overall pattern of economic disadvantage in many rural areas. The historical and defining features of rural economies often constrain development. Regardless of other differences, efforts to assist rural areas must take into account three common rural characteristics: (1) rural settlement patterns tend to be small in scale and low in density; (2) the natural resource-based industries on which many rural areas have traditionally depended are declining as generators of jobs and income; and (3) low-skill, low-wage rural labor faces increasingly fierce global competition.

Connecting rural America to the digital economy and raising the skills of workers and leaders will be essential to compete more effectively. A third of all rural counties captured three-fourths of all rural economic gains in the 1990s. This concentration of economic activity is the result of powerful shifts in demographics, technology, and business practices. And while rural America has often based its development on relatively low labor costs, future opportunity will be based more on skilled workers and capital investments (Drabenstott, 2000).

Contextual Issues

Issues for rural schools vary from one community to the next. Each reveals a valuable message for those seeking to understand the rural context. While not claiming to be an exhaustive list, or that one issue is more important than another, several salient issues are highlighted in this paper: namely, community vs individual well-being, schools as partners in rural development, adequate funding, setting standards, school size, school facilities, diversity and poverty, school improvement capacity, teacher recruitment and retention, leadership, policy action, and research.

Community vs Individual Well-Being. Should we assume that principals and teachers in our rural schools care about the place their students live, and the values parents hold for their children and the school? Are cultural values associated with the rural way of life at times in the way of "progressive education?" Modern society rewards individual mobility and prosperity, where "moving up" and "moving out" mean the same thing to rural youth-and many of their educators. Adults and youth who desire to stay in a rural place are usually labeled with low aspirations, persons who obviously are not considered among the "best and brightest." They refuse to seek greater personal achievement and prosperity offered in urban America. Can we have both a rural quality of life and an "urban-minded" education (Harmon and Branham, 1999)?

Researchers and education reformers that seek to always compare rural educational issues in the context (or shadow) of urban values should reflect on Howley's (2001) comments carefully. Otherwise, they should be satisfied with results of their work that yield little impact on the realities of rural schools, their students, and their communities. Haas and Nachtigal (1998) contend our country tends to measure education success by individual profit, having forgotten that the top priority of schools is to serve the public good. The philosophy of *living well* is most closely associated with the American rural way of life, a life characterized by production and sufficiency. But the chase for the *good life* is depleting community after community. Rural schools, they contend, have contributed to this process by educating students to take their places anywhere in the global economy-and ignore the fact that *anywhere* usually means *elsewhere.*

Schools as Partners in Rural Development. Advocating survival and revitalization of rural areas by building and sustaining strong linkages with local public schools is not a new idea. In the book, *Teaching the Commons: Pride, Place, and the Renewal of Community,* Theobald (1997) maintains:

> By attending to place, rural schools can begin to set a new institutional trajectory for formal education in this country. Rather than promote a simplistic agenda that can be described accurately as equipping children with the factual knowledge needed by future employers, the global economy, or the Educational Testing Service, the school could become an agent for the restoration of community. It could do this, in part, by encouraging children to explore the wisdom inherent in elevating the common good above their own individual desires. This is an idea with a long tradition in the West, an idea that has been effectively buried in this country by our feverish consumer culture. (pp. 2-3)

Many rural advocates have promoted the need for schools to "reform" in ways that build on the central role schools must play in the life of communities, as well as the individual student, if it is to be a viable institution. Otherwise, well-meaning educational reform initiatives have limited chance for success, particularly if the reform is to be sustainable. Thinking globally and acting locally in ways that value rural places is not easy in a policy environment that seldom views community development as a traditional or essential role of "schooling." Kretzmann and McKnight remind us:

> As schools have become more professionalized and centralized, they have tended to distance themselves from their local communities. The vital links between experience, work, and education have been weakened. As a result, public and private schools in many rural and urban communities have lost their power as a valuable community resource. And many economically distressed towns, communities, and neighborhoods have begun to struggle toward economic revitalization without the valuable contributions of the local schools. (p. 209)

Former US Secretary of Education Richard W. Riley recently asked the nation to follow the example and leadership of rural communities in resisting the trend toward separation of schools from communities (Rural School & Community Trust, 1999). He challenged rural communities to lead by example in the battle to make schools the centers of community. If such leadership is to occur, policymakers must develop a better understanding of the circumstances confronting rural schools in the larger context of their communities-and develop policies that invigorate the role of schools in rural development (Harmon, in press).

Adequate funding. Rural school districts, with their modest fiscal bases, usually cannot generate sufficient local resources to supplement adequately the state school finance programs the way that more affluent localities can. Numerous supreme courts have ruled their state system of school funding as unconstitutional and have ordered new systems be developed. While equity and efficiency arguments have been prevalent in most of these cases, the current court challenges also are highlighting the need to provide a level of funding for providing "adequate" educational opportunities if students are expected to meet state-mandated standards of performance.

In reviewing school finance litigation reported by the Education Commission of the States (March, 2000), Marty Strange, director of the Policy Program for The Rural School and Community Trust, suggests 18 is an accurate count of unconstitutional state funding systems, if one includes two states (AL and MO) where a lower court ruling effectively served as a final decision because the state didn't appeal or the Supreme Court did not accept the case. The 18 states include: AL, AZ, AR, CA, CT, KY, MA, MO, MT, NH, NJ, OH, TN, TX, VT, WA, WV, WY.

States where the public school funding system has been upheld include: AK (although a lower court just ruled it unconstitutional on facilities finance, and it is headed for appeal), CO, GA, ID (new case pending on facilities), MY, MI, MN, ND (Supreme Court voted 4-3 that it was unconstitutional, but 5 votes needed to sustain a finding on unconstitutionality), NY (new lower court ruling that the system is unconstitutional, headed for long judicial and political battle), OK, OR, PA, RI, WI, VA. Also, in three of the states where the court overturned the funding system (AZ, OH, WA) it had earlier upheld it in another case. New court cases that focus on facilities alone are active in AK, AZ, NM, CO, ID.

Setting standards. Americans want schools where students must meet some "standard" of achievement. But who sets the standard is a critical issue being debating in rural schools and their communities. Local versus state (or federal) control of public schools is at the center of the controversy of setting standards. Rural schools and community advocates such as The Rural School and Community Trust, for example, believe that standards should originate within the community in which the students live. Others argue that it is the state that should set standards because local schools in some rural areas traditionally have low expectations for student achievement, as well as taxpayers with low interest in funding "high standards for all students."

Some rural interests argue also that rural communities cannot afford to fund the requirements for state-mandated standards, and school consolidation-in the name of fiscal efficiency-is the likely result. On the other hand, some policymakers also believe federal and state interests in having an educated citizenry for competing in a global economy compels standards be set at the state level, with the local schools having flexibility to decide "how to teach" the content, rather than "what to teach."

For the first time in our nation's history, nearly all states have developed standards for public education. The 31st annual Phi Delta Kappan/Gallup poll of the public's attitude toward public schools (Rose and Gallup, 1999) reveals that of the approximately 1,100 people participating in telephone interviews (25% representing a rural community):

- A majority (57%) believes that the standards currently in place are about right
- A strong minority (33%) believe the standards are too low
- Almost half of the non-whites (48%) and urban dweller (43%) are the groups most likely to feel standards are too low
- Only 3% of the respondents in rural America thought the standards were too high, 63% thought they were just about right, and 29% thought they were too low (5% "didn't know")

Kannapel (2000) believes some middle ground exists between those who advocate state-level determination of standards and those who believe local communities should set the standards. This debate will likely accelerate as state funding formulas for public education and high stakes testing and accountability play out in the context of what is considered "adequate" educational opportunities and who pays the bill. Charter schools and other forms of public education "choice" may also play a role in whether "community schools" survive or thrive in the new millennium. Intertwined also in the issue is how the rhetoric of parent and community involvement becomes reality, or whether public education is reduced to serving only certain segments of the public (e.g., the impoverished).

School size. The majority of schools in rural setting are small, enrolling fewer than 400 students. Only 2 percent have enrollments exceeding 1,200 students. Research reveals that a high school with an enrollment of 400 students is able to offer a reasonably comprehensive curriculum, and that a high school ought not to enroll more than 600 to 1,000 students. Schools with high populations of students from low-income families do best academically in small schools.

Public concerns regarding school safety issues also reinforce the need for small schools, where teachers know students well, and students have a feeling of belonging in the school and community (Howley, 2000). The book, *Small High Schools That Flourish: Rural Context, Case Studies and Resources* (Howley and Harmon, 2000), profiles four small high schools in the U.S. that have accepted the challenge of taking their own paths to serve students and their communities well.

School facilities. While rural schools may be located in some of America's most beautiful areas, in 1996 about 4.6 million rural students were attending schools in inadequate buildings (National Education Association, 1998). Three out of ten rural and small town schools have inadequate buildings. One in two schools have at least one inadequate building feature. Approximately one-half have unsatisfactory environmental conditions in the buildings. Thirty percent of schools in rural areas report at least one inadequate building. Fifty-two percent of rural schools report at least one inadequate building feature, such as a roof, foundation, or plumbing (U.S. GAO, 1996). Approximately 37 percent have inadequate science laboratory facilities, 40 percent have inadequate space for large-group instruction, and 13 percent report an inadequate library/media center (U.S. GAO, 1995).

Technology needs also force building modifications. Many older schools lack conduits for computer-related cables, electrical wiring for computers and other communications technology, or adequate electrical outlets. Without the necessary infrastructure, however, schools cannot use technology to help overcome historical barriers associated with ruralness and isolation. In 1990, $2.6 billion was estimated to be needed for funding maintenance on existing buildings and almost $18 billion to replace obsolete rural schools. The issue of funding rural school facilities continues to receive high interests among policymakers (Dewees and Hammer, 2000; Dewees, 1999). Wireless" technology obviously will introduce new issues as rural communities debate the desire and affordability of renovating or building schools in rural areas.

Diversity and poverty. Addressing issues of education in rural areas include confronting the realities of people in poverty and the growing diversity of rural America. A special report on socioeconomic conditions in rural America by the United States Department of Agriculture (February, 1999) reveals the circumstances of who lives in rural areas.

Geographic diversity best defines the issue of diversity in rural America. Using 1990 Census data, 333 of the 2,288 rural counties have a minority group that makes up one-third of the population. These counties contain only 12 percent of the total rural population. However, they are geographically clustered according to the residents' race or ethnic group. Multicultural education issues are "hot topics" in many rural communities today.

Rural minorities often live in geographically isolated communities where poverty is high, opportunity is low, and the economic benefits deprived from education and training are limited. Rural counties with one-third or more Black population are found only in the South. Native American (American Indian, Alaskan Native) counties are clustered in three areas: the northern High Plains, the Four Corners region in the Southwest, and Alaska. Most of the Hispanic counties lie near the Rio Grande River, from its headwaters in southern Colorado to the Gulf of Mexico. Hispanics are the fastest growing rural minority group. Agricultural areas in Washington, ski resorts in Colorado, and meat packing centers in Kansas, Nebraska, and Iowa have seen new or greatly expanded Hispanic settlements in the 1990s.

According to a task force on persistent poverty of the Rural Sociological Society (Summers and Sherman, 1997), nearly 10 million poor people live in rural America, almost one in every five rural residents. A "poverty gap" exists between rural minorities and the white population. Rural minorities are significantly more impoverished as a percentage of the population. The overwhelming majority, however, of poor people living in rural America are white (72.9 percent). Less than one-fourth are African Americans (23.6 percent) and Hispanics make up only 5.4 percent of the total. Less than 5 percent are Native Americans. These facts contradict the widely held notion that poverty in the United States is a minority problem. These people are the "working poor" in rural America.

Addressing educational opportunities and results will require solutions to both the poverty gap of minority groups and the persistent impoverished conditions of all rural poor, especially those who work for low wages. This is no easy task, as "...social problems are seen as having their origin in political and economic structures beyond the control of most people who live in rural America" (Moore, 2001, p. 13).

School improvement capacity. Major initiative in the 1990s, such as the National Science Foundation Rural Systemic Initiative, the federal government's Comprehensive School Reform Demonstration Program, the Annenberg Foundation's Rural Challenge (now the Rural School and Community Trust), and the US Department of Education's Regional Educational Laboratory program have each in their own way attempted to give targeted assistance to rural school systems.

Increasingly, rural school districts are relying on regional educational service agencies (ESAs) as vital partners in school improvement efforts. In the book, *Expanding the Vision: New Roles for Educational Service Agencies in Rural School District Improvement,* Stephens (1998) calls on ESAs to pursue strategic goals that will enable them to be the first-line school improvement support for their rural school districts. ESAs are particularly important in giving rural schools the capacity to educate students with special and exceptional learning needs. The Association of Educational Service Agencies (AESA) is the national professional organization serving education service agencies (ESAs) in 33 states.

Teacher recruitment and retention. Attracting and retaining quality teachers will be critical in creating and implementing higher standards for student academic achievement (Harmon, 2001). According to the report "The Supply and Demand of Elementary and Secondary School Teachers in the United States," for the 1998-99 school year, there were 2,780,074 teachers in public schools. More than a million of those teachers (approximately 40 percent) were in the six states of California, Florida, Illinois, New York, Ohio, and Texas. These six states also have almost 1,400 rural school districts. The number of elementary and secondary school teachers is projected to increase by 1.1 percent annually to a total of 3.46 million by the year 2008. Urban and poor communities will have the greatest need for teachers, with more than 700,000 additional teachers needed in the next decade.

The rural teacher shortage affects all subject areas but particularly math, science, and special education. According to the National Association of State Boards of Education, an adequate number of teachers are trained each year. The problem is with distribution. Causes for a teacher shortage in rural areas include: social and cultural isolation, poor pay and salary differentials, limited teacher mobility, lack of personal privacy, rigid lockstep salary schedules and monetary practices, luring of teachers away by higher paying private sector businesses and industries, strict teacher certification practices and tests, lack of reciprocal certification to enable teaching in another state, recruitment cost (time/costs to gather information), and a high rate of teacher turnover (Harmon, 2001).

In 1998, the National Education Association used data primarily from studies conducted by federal agencies to describe public education in rural areas and small towns compared to central city schools and urban fringe schools. A few of the comparisons were:

Of the approximately 2.56 million public school teachers, approximately 40 percent are in rural and small town schools. Compared to teachers in central city schools and urban fringe schools, rural teachers tend to be less well educated, slightly less experienced, younger, and less likely to belong to a minority group. Rural school principals are more likely to be male and less likely to belong to a minority group compared to principals in central city schools and urban fringe schools.

Teachers of rural and small town schools spend more time being with students at school and outside school hours, have smaller incomes, and are less likely to have benefits of medical insurance, dental insurance, group life insurance, and pension contributions.

Teachers in rural and small town schools perceive student use of alcohol to be a more serious problem, and less likely to perceive a serious problem in student absenteeism, tardiness, verbal abuse of teachers, and student disrespect for teachers. Teachers in rural schools are less likely than teachers in central city schools, but more likely than teachers in urban fringe schools to perceive poverty as a serious problem in their schools.

Leadership. The most critical issues in managing and running small rural school districts are finances, regional economic conditions, state regulations, salaries, and providing an adequate variety of classes. The greatest turnover among superintendents occurs among the smallest districts, those with fewer than 300 students. An environment of high stakes testing and increasing public accountability for student and school success is placing a premium on persons that can effectively lead schools (and school districts).

Chalker (1999) points out in the book, *Leadership for Rural Schools: Lessons for All Educators,* that being an effective principal in a rural area means building positive relationships with the people in the rural community. The school in the rural community is still a respected institution, with a lot more focus on "people" than on "business."

Building trust and finding ways to make the curriculum incorporate the strengths of the community are key features of successful school leaders in rural areas. In the decades ahead, leading rural schools and school systems in ways that contribute to community and economic development appear essential for sustaining a prosperous school and community in much of rural America.

Policy action. Lack of a precise demographic "rural" definition frustrates those who work in setting educational policy. In 2000, and for the first time in history, an organization-The Rural School and Community Trust-systematically attempted to gauge and describe the relative importance of rural education in each state. This first effort used both *Importance* and *Urgency* gauges. Results reveal a cluster of seven states where rural education is crucial to the state's educational performance and where the need for attention is great: Alabama, Arkansas, Mississippi, Kentucky, West Virginia, North Dakota, and South Dakota.

These states are in regions that are chronically depressed, suffer large areas of out-migration, and are deeply distressed by changes in the global economy. Louisiana, Montana, and Oklahoma round out the top ten states where rural education is important and needs for policy action are urgent. The fact that 25 states now have affiliate organizations with the National Rural Education Association also reflects the growing trend for rural education interests to unite and seek solutions to public education issues.

Research. DeYoung (1991) points out in the book, *Rural Education: Issues and Practices,* that rural educational issues rarely attract the attention of prestigious colleges of education and their professorates. Part of the reason is that rural areas are places with traditions and cultures of labor and of working, rather than demand for intellectual understanding and for abstract scholarship. Scholarship on rural education is relatively underdeveloped in the United States (DeYoung, 1987).

In the report to The Rural School and Community Trust, *Where Has All the 'Rural' Gone? Rural Education Research and Current Federal Reform,* Sherwood (2001) points out:

> ... intense study of rural schools has suffered from a lack of consistent support by government and academic institutions, largely due to: 1) lack of appreciation for urban-rural differences; 2) lack of academic appeal comparable to the excitement generated for urban work; 3) relatively little networking in the professional and research communities around rural education research; 4) a paucity of professionals devoting their careers to continuous study of rural education; 5) longstanding lack of consensus concerning rural education's domain and research priorities; and, finally, 6) a lack of the sense of crisis associated with urban schools, and the accompanying focus by policy makers. (p. 3)

Sherwood (2001) reports that the challenges of rural research appear enmeshed in demographics, politics and diminishing returns. Federal education R&D Centers are usually located at major universities in metropolitan areas. Sherwood (2001) concludes:

> A summer 2000 review of research project descriptions and titles available on centers' web pages revealed one study focusing exclusively on rural issues, and few that contained any mention of "rural" at all. Even among those studies showing interest in rural education, the attention appeared cursory. One study claimed to explore contrasts between "schools serving relatively affluent, suburban communities and schools thought to be potentially at risk: those serving inner-city, economically disadvantaged communities and those in more geographically remote rural areas." The study examined nine inner-city schools, compared with only two rural ones "because inner-city students were considered most at risk." (p. 5)

In 1996, rural education researchers Harmon, Howley, and Sanders reported in the *Journal of Research in Rural Education* that 196 doctoral dissertations were written between 1989 and 1993 on the topic of rural education. Since 1997, the US

Department of Education's Office of Educational Research and Improvement has operated Regional Educational Laboratories authorized by federal law to devote 25 percent of their funding to meeting the needs of rural schools, part of which has been the conduct of applied research. In 1996, the Education Department designated one of the labs as the Rural Education Specialty on behalf of the network of labs, a practice that ended in 2001 with the start of a new five-year contact for the regional educational laboratories lab program.

Sherwood (2001) also comments on this phenomenon:

> Under the 1996 contract, 25 percent of the entire lab program budget was to be dedicated to rural district services, a stipulation that survives in the 2001 agreement. Yet, the Department of Education has been hard-put to show adequate monitoring of this spending guideline. While ORAD can point to some impressive rural programs by individual labs (which are obligated to assess their own services to rural constituencies), there is currently no coordinated dissemination of rural-specific lab products to rural districts, no close monitoring of funds dedicated to "rural" at the national level, no coordinated nationwide effort of "rural" as an object of examination, nor any national program focusing exclusively on rural education issues. (p. 10)

Inadequate attention to research in rural education is an issue of local, state, regional, and national interest-and an issue likely to become more critical as increasing accountability and results are expected from public investments in education. Stern (1994) notes:

> Lack of adequate research and impact evaluations, together with definitional inconsistencies severely limit policy makers' ability to know either the effect of federal, state, and local programs on rural schools or whether rural interests are being equitably addressed. Until this deficiency is corrected, policy making on behalf of rural students will be impeded." (p. 31)

Conclusion

Addressing educational issues of public schools in rural America will require thoughtful research and reform-minded assistance that differentiates between the "old story" of rural education and the emerging "new story" (Haas (1990), a paradigm change that combines rural education and the rural economy in a way that strengthens them both. The old story reflects society's continuing shift from agriculture to industry and from industry to information. It suggests that rural schools have two purposes, to educate students either as participants in communities that [illegible]erpetually dependent on natural resources, or to take their [illegible]s in urban industrial America. The result has been steady decline for most rural communities, particularly those not adjacent to an urban area, as America enjoyed its greatest economic prosperity in history.

If rhetoric can become reality, opportunities for a new story of public schools and their communities forming partnerships for prosperity may be on the horizon. The education agenda of "No Child Left Behind" being advocated by President George W. Bush-who was clearly elected by carrying the votes of "rural" states-holds promise for closing the educational disparities and achievement gaps prevalent in rural schools of America. The debate is starting in states and communities is regarding how such an agenda is likely to impact funding, accountability, and community control of local rural schools.

The "new story" says the mission of rural education is to meet student needs while addressing community needs. Promise exists for improving opportunities for rural children and communities as rural schools adapt to changing economics, demographics, and societal expectations. Key characteristics of rural education in the new story are decentralization, diversity, low bureaucracy, parent and community engagement, evolving higher academic standards and outcomes, continuous improvement, high value for flexible generalists, small scale (small, safe and caring schools), and technology enhanced.

Innovations in telecommunications increase the capacity of rural schools to give students, educators, and the community access to enormous educational opportunities and connections to the outside world, regardless of geographic location in America. While the curriculum rural schools offer may be "place-based," one's employment opportunities and life's work in the near future may no longer require moving away or commuting long distances to a place of work. The Internet and other technologies make working and living in rural America a viable option, particularly for those with lifelong learning and entrepreneurial skills.

Schools should provide educational opportunities and linkages for students who choose to stay in rural America, as well as for those who leave. Local school boards have an important role to play to establish policies that reconnect schools and communities. Democratic schools with limited bureaucracy will be prevalent in the "new story" of rural education. Curriculum and assessment will be redesigned for authentic, relevant learning. Course delivery, with rigor and relevance for all students, will more closely reflect learning situations students experience throughout their lives. Teachers are highly qualified generalists trained to help students (and each other) find and use information, feel safe, and care about their place of residence (rural or urban). Schedules fit the task. School facilities fit the community's needs. And interdisciplinary research builds the bridges of best practices for rural schools, their students, and their communities to prosper in the 21st century.

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Science Education Contextual Issues

The major focus for science education as a discipline is understanding each of the title words: science, education, contextual, and issue. Although most are content to define science as the information found in textbooks for K-12 and college courses or the content outlined in state frameworks and standards, such definitions omit most of what characterizes science. George Gaylord Simpson (Simpson, 1963) once described science as consisting of the following:

1) asking questions about the natural universe, i.e., being curious about the objects and events in nature;

2) trying to answer one's own questions, i.e., proposing possible explanations;

3) designing experiments to determine the validity of the explanation offered;

4) collecting evidence from observations of nature, mathematics calculations, and whenever possible experiments that could be carried out to establish the validity of the original explanations;

5) communicating the evidence to others who must agree with the interpretation of the evidence in order for the explanation to become accepted by the broader community (of scientists).

This definition is one that can be accepted by most. And yet it rarely indicates any feature of science that is studied in schools. Students rarely determine their own questions for study; they are not expected to be curious; they rarely are asked to propose possible answers; they seldom are asked to design experiments; they never share their results with others as evidence for the validity of their own explanations. **One could argue that real science is never encountered or experienced in most classrooms.** The typical focus is almost wholly on what current scientists accept as explanations. Good science students only need to remember what teachers or textbooks say. Most laboratories are but verification activities of what teachers and/or textbooks have indicated as truths about the natural world.

Education means drawing people out in terms of engaging their minds. Again, most schools focus on informing students as to what they should learn - i.e., the explanations of objects and events that scientists have accepted as truths. Education has become training, i.e., getting students to accept and able to recall explanations others have offered.

Too often science education has been defined as a two dimensional enterprise. The first (and most important) consists of the concepts (the constructs generally accepted as explanations of the objects and events found in nature). For over a hundred years reformers have identified certain skills used by scientists as equally important to the basic concepts that should be considered in the study of science. These skills are often called processes; they too have been used to define school science - but often to a much lesser degree than the conceptual themes used to organize typical courses. Some still accept a two dimensional view of science education with the concepts being taught (and learned?) in science courses and process skills being taught (and learned?) in education courses. To accept that science education consists only of the current constructs of the natural world accepted by today's scientists and the skills they have used in determining these constructs results in missing the essence of the enterprise at least from the point of personal involvement.

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The importance of context is now apparent. In fact the context for learning is more important in promoting learning than are the concepts and the process skills per say. These represent important outcomes for science teaching; but, they do not help achieve understanding unless there is a real world situation (context) for seeing, learning, and using the ideas and skills which are often portrayed to exemplify school science. Establishing an appropriate and relevant context for learning science is a requisite for learning concepts and processes. And, the student must help develop the context if it is to be seen as important and useful. Often the best context for learning occurs when issues (questions, problems, concerns) are used to define it.

The importance of context in science education was realized after the cognitive science research revealed the inadequacies of typical instruction (Champagne & Klopfer, 1984; Resnick, 1987). When university science and engineering majors were studied, it was found that 85-90 percent of these very interested and capable students had no real understanding. They were merely conscientious students who committed important concepts and skills (often mathematical equations) to memory.

The minds of most students were not engaged. Perrone (1994) has reported on the ways student minds can be intellectually engaged. Chief among his points were:

1. Students must help define the content - often by asking questions;
2. Students must be given time to wonder and to find interesting pursuits;
3. Topics often have "strange" features that evoke questions;
4. Teachers encourage and request different views and forms of expression;
5. The richest activities are "invented" by teachers and students;
6. Students create original and public products that enable them to be "experts";
7. Students take some action as a result of their study and their learning; and
8. Students sense that the results of their work are not predetermined or fully predictable.

After student minds are engaged, learning can and is likely to occur. Reinsmith (1993) has described some situations (contexts) that determine real learning. Major factors include:

1. Real learning results from trial and error;
2. Students only learn when they have some success and interest in the field;
3. Students have to believe that they can learn;
4. Real learning connotes use;
5. The more learning is like play, the more absorbing it will be;
6. Time must be wasted, tangents pursued, side-shoots followed;
7. Learning never occurs outside an appropriate context; and
8. Typical tests are very poor indicators of real learning.

If learning is to occur, changes in teaching must occur. The National Science Education Standards have captured the essence of the changes needed in teaching. The following list indicates these changes needed in science teaching with the less emphasis column indicating typical teaching situations - the right hand column indicating the visions for needed changes. (National Research Council, [NRC], 1996):

Less Emphasis On

Treating all students alike and responding to the group as a whole

Rigidly following the curriculum

Focusing on student acquisition of information

Presenting scientific knowledge through lecture, text, and demonstration

Asking for recitation of acquired knowledge

Testing students for factual information at the end of the unit or chapter

Maintaining responsibility and authority

Supporting competition

Working alone

More Emphasis On

Understanding and responding to individual student's interests, strengths, experiences, and needs

Selecting and adapting the curriculum

Focusing on student understanding and use of scientific knowledge, ideas, and inquiry processes

Guiding students in active and extended scientific inquiry

Providing opportunities for scientific discussion and debate among students

Continuously assessing student understanding

Sharing responsibility for learning with students

Supporting a classroom community with cooperation, shared responsibility, and respect

Working with other teachers to enhance the science program

The goals for science education have changed–often as reforms have called for moves to finding and using current issues and other personal, current, or meaningful contexts for learning. As early as 1946, the American Association for the Advancement of Science (AAAS, 1946) called for changes in science teaching that would provide functional (useful) learning. This focus was altered in the 60's with the scare provided by the Soviets with their space exploits. The U.S. moved to a focus on the constructs and skills known to scientists as appropriate for all learners (Harms & Yager, 1981). The 70's resulted in disillusionment with the science "known to scientists" with a new move to science that could affect the thinking and the lives of all. Project Synthesis (1981) established the importance of four goals for science education, namely:

1 Science for meeting personal needs. Science education should prepare individuals to use science for improving their own lives and for coping with an increasingly technological world.

2 Science for resolving current societal issues. Science education should produce informed citizens prepared to deal responsibly with science-related societal issues.

3 Science for assisting with career choices. Science education should give all students an awareness of the nature and scope of a wide variety of science and technology-related careers open to students of varying aptitudes and interests.

4 Science for preparing for further study. Science education should allow students who are likely to pursue science academically, as well as professionally, to acquire the academic knowledge appropriate for their needs.

All but the fourth goal illustrates science in context.

These goals became central to the National Science Education Standards (1996). However, the goal of teaching science as preparation for further study was dropped in favor of one that encouraged every student to experience the kind of science defined by Simpson (1963). These four goals indicate that students should:

1 experience the richness and excitement of knowing about and understanding the natural world;

2 use appropriate scientific processes and principles in making personal decisions;

3 engage intelligently in public discourse and debate about matters of scientific and technological concern; and

4 increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers.

This history and these new directions are most appropriate for science education in rural Appalachia. They are appropriate for all - but the setting being Appalachia provides a special context for student learning. Some of the uniqueness of science learning in rural settings should provide the special context for the learning. One of these is the sheer number of students and people that comprise a community and/or a school district. This means fewer students in a grade level and less diversity in terms of parent vocations and socio-economic levels. It also often means strong community bonds. It means a certain closeness to nature and local folklore. It often means fewer specialized teachers of science who are more frequently teaching outside their major field of interest or specialization.

And yet, the rural setting is often one where there is more interest in education and what it can provide for students. It is easier to use local experts, local facilities, local businesses to participate and be involved in science study. The community helps identify issues and provides the context for school science.

Five situations provide the hope and emerging evidence that our current efforts at reform are "on-the-mark" and succeeding. They also indicate areas for questioning and follow-up research. Continued efforts with evaluating and renewing our expertise in each area suggest that the next several years will be exciting ones - ones which will allow us to envision even more inconceivable improvements and exciting possibilities to assess our successes.

First of all, we now realize the power of collaboration and the importance of all stakeholders being involved in creating the visions and in the efforts to realize them. This certainly was (and is) the position of Project 2061 (AAAS, 1988) and the rationale for systemic reforms and the teacher education collaboratives supported by the National Science Foundation. As more people establish systemic reform projects and as the funding continues and encourages the moves, change will occur more quickly; it will be re-enforced with the evidence that assessment provides when it is more broadly conceived to meet all the goals.

A second factor attributing to the likely success for realizing our immediate goals for the next few years will be changes in teaching and the effect such changes will have on students. Such students will be more scientifically literate and possess scientific habits of the mind. The successes will demand changes in instruction where there is often information personally collected and used in making even more decisions, establishing new goals, and determining new ways of meeting them. One is reminded of Carl Sagan's comment that all people start out as scientists: "Everybody starts out as a scientist. Every child has the scientist's sense of wonder and awe." (National Research Council, [NRC], 1998). We need to recognize that all of these essential aspects of science are missing in most school programs. **Student questions rarely frame instruction; students rarely are asked to predict possible answers; students rarely design their own experiments to test the validity of their answers; students seldom debate the conclusiveness of their answers/experiments; students rarely compare the results of their work to others as evidence.** Many activities are now conceived to be open-ended; however, it is rare to find open entry and choice for designing experiments and collecting evidence in the middle. Some would argue that typical instruction in schools where science concepts are taught directly to students causes most to miss these most important aspects of the human enterprise called science.

Every teacher, every student, every human must be empowered to wonder, to suggest explanations, to devise ways of testing personal and class hunches that are offered to explain the objects or events in question, to collect and analyze evidence, to communicate the process and the results to others. Research can not be left only to the professionals. Action research in schools and daily lives needs to be central to science teaching and learning. To learn science means to engage in it as opposed to learning about what others have done.

A third reason for optimism that we will succeed with current reforms is the latest research on human learning. Our knowledge of how all people learn puts us in a powerful position to succeed in ways never before possible. We must make teaching more of a focus and utilize research about teaching instead of viewing our mission as merely transmitting the conceptions of nature which scientists now accept as valid explanations. We want and need people who can think, solve problems, make decisions based on evidence and reasoning. The NRC (1999) book on how people learn includes an appropriate epilogue:

Developments from a diverse array of sciences have altered conceptions of learning in fundamental ways. The cumulative knowledge from these sciences delineate the factors that contribute to competencies in reasoning and thinking. The new developments are ready to take learning science another step and focus on processes that promote learning with understanding.

If the current research is put to use by science teachers and other school leaders, the next decades will be a golden times as we succeed with developing a citizenry that is scientifically literate.

A fourth basis for optimism is the wonder and success of computer technology. Never has a technological advance been so important in human affairs. Surely the future will be shaped as computer technology advances - in many respects allowing everyone to do more than would be possible in terms of time and use of the human brain. Computers allow us to locate information with speed and efficiency; they analyze and report data; they allow us to see things happen that would normally take a lifetime. Our imaginations have only begun to tap the potential of this technological achievement.

A final factor that provides optimism for even greater successes with meeting the goals of scientific literacy for all is a new focus on science teacher education.

More recently Yager has headed two major research efforts funded by the U.S. Department of Education - Salish I and Salish II - (Salish Research Consortium, 1997; Robinson & Yager, 1998). These studies reveal that:

1. Most new science teachers use little of what teacher education programs promote during their initial years of teaching;
2. Few teacher education programs are utilizing what we know about science as envisioned by NSES;
3. Programs are poorly conceived in terms of sequential experiences with science teaching; these are unrelated to the general education and science courses that comprise most of a Bachelor's program;
4. There are few ties between pre-service and in-service efforts;
5. Support for teacher education reforms have been largely unrecognized and under-funded; only in the last few years has this situation been altered;
6. When part of a collaborative research project, significant changes in teacher education majors can be made during a single year;
7. There is strength in diversity of institutions and faculty involved with science teacher education;
8. Changes in science instruction at colleges must be substantial if real improvements are to occur in schools; and
9. Collaboration in terms of experimentation and interpretation of results is extremely powerful.

New efforts to fund centers for science and mathematics teaching and learning provide even more optimism about teacher education that will reflect and use all aspects of the five factors identified that provide optimism for realizing successes over the next 20 years.

The points for optimism also outline needed research in science education if the possible successes with science education in the Appalachian region are to occur over the next quarter of a century. The region offers an excellent context for making it happen. The "Appalachian Rural Systemic Initiative" has provided the vital first steps. Science teachers must take a major responsibility for changing their teaching and transforming it into a science. They must ask questions about science, about processes, about varied contexts for learning. They must help students question better, to propose ideas that respond to questions, to design tests, to establish the validity of their explanations, to help students communicate their results and the interpretations offered as evidence. And most importantly, students must be helped to use their learning in new contexts and thereby provide real evidence that learning has actually occurred. **When science has been learned, it becomes a functional part of the learner.**

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"Best Practices" in Mathematics Education from an International Perspective

Describing "best practices" in mathematics education presents one central problem: "best" by what standards? Certainly we know quite a bit about what makes effective practice by US standards and could define "best" practices from that. However, as TIMSS has shown US "best" practices do not appear to be good enough from an international perspective. US students at third, fourth, seventh, eighth, and twelfth grades were at best about at the international average in achievement and often were far below this in mathematics learning.

The practices that created that situation can only be called "best" by a stretch of the imagination and by putting blinders on so that we view things only from the US perspective. **Our real goal is to produce students who have a deep and skillful ability to use mathematics in practical ways.** We want to produce persons who are suitable for the demands of an increasingly technological society that must compete in an international marketplace. The US cannot afford for the sake of its future to wear any kind of blinders to what is truly best in mathematics education.

This is not to say that the US should import without thought the mathematics practices of other countries and cultures. US mathematics education deals with US students in a US context. What is done must work here. What will work here is the subject of further research. What will work in the especially demanding setting of rural education is a subject for further specialized research. However, to even have a clue as to what that research should be, one needs to know what can be known about what has been seen to be effective in an ineffective system nationally. This paper will try to describe some important findings from that cross-national perspective.

Stop wasting the middle school curriculum

One important lesson from TIMSS is that the US essentially wastes the middle school curriculum by excessive review and by covering again, mainly arithmetic, topics that have been covered in previous grades. This is not true in most other countries and certainly not in those that were high achieving countries in TIMSS. The evidence for this is clear.

Considering just for a moment the "A+" countries, those that had the highest achievement, it can be seen that they also had the most demanding curriculum during the middle grades. This is true whether one looks at their standards, their textbooks, what their teachers cover, or how their instructional time is used. Table 1 shows the top five topic areas in the content standards documents of the countries that achieved the highest in the eighth grade TIMSS mathematics test. Notice that of these five topics, three are geometry while two are core topics in algebra. This focus on algebra and geometry in the seventh and eight grades is typical of high achieving countries. By contrast, the US focuses on fractions and arithmetic topics except for that small minority of students that take Algebra I in eighth grade.

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Table 1. Top Five Topic Areas in Curriculum Standards of High Achieving Countries in Eighth Grade Mathematics

Equations & Formulas
Patterns, Relations & Functions
2-D Geometry: Polygons & Circles
Congruence & Similarity
3-D Geometry

The same is true if one looks at the top five topics in eighth grade textbooks in high achieving countries with one difference. "Congruence and similarity" drops to the sixth most emphasized topic and is replaced in the top five by "perimeter, area and volume" which is a topic that mixes geometry and measurement but which is also not emphasized in the US.

The picture changes slightly if one focuses on what teachers actually cover in their classrooms at eighth grade in these countries. Table 2 gives the top five topic areas covered by eighth grade mathematics teachers in the high achieving countries. Notice that some of the geometry topics are gone as is material on functions. For the first time, there is an emphasis on common and decimal fractions and on number sets (integers, rational numbers, etc.). This is still far more demanding than what is typically covered by US eighth grade teachers. If one looks at how those teachers focus their instructional time in the high achieving countries one will still find the same five topic areas although in a different order.

Table 2. Top Five Topic Areas Covered by Teachers of High Achieving Countries in

Eighth Grade Mathematics
Equations & Formulas
1D & 2D Geometry Basics
Perimeter, Area & Volume
Common & Decimal Fractions
Number Sets & Concepts

The point to these data is not the specifics of what is focused on in eighth grade mathematics in high achieving countries but rather that their curricula are far more demanding than the corresponding curricula in the US. What is true of eighth grade is true of the middle grades more generally. "Best practices" would seem to require spending instructional time on far different topics than is usually done in the US middle grades.

The TIMSS results allowed US mathematics curricula to be characterized as being "a mile wide and an inch deep." These curricula tried to cover something of every mathematics topic but given limited mathematics instruction time, could then spend only a little time on any one topic. As a result all topics are covered shallowly emphasizing only simple facts and routine procedures with comparatively little work in problem-solving, reasoning and higher order thinking skills in mathematics.

This is not true of mathematics curricula across the grades in high achieving countries. Far more typical is a pattern that focuses on a few key topics at each grade and covers them in considerable depth. Over the sequence of grades these focus topics are rotated through the necessary topics so that everything is eventually covered with somewhat more focus than is the case in the US. What is lost is excessive review of topics in grade after grade. Internationally higher achieving countries seem willing to assume that students can master content once and for all without losing it if they continue to use it in other mathematics and that perpetual review is not necessary. "Best practice" seems to make that assumption. That is not the typical assumption in the US, either in the new or old NCTM standards or in most state standards. Changing that is essential for "best practice" in mathematics education in the US.

Demand more from students

Perhaps as a consequence of the large number of topics that mathematics teachers are expected to cover each grade, any one topic receives only limited attention. Even those that receive the most attention receive only a few periods of coverage. That limited attention seems to be reflected in how deep the topics are covered and in what is expected of students. In the US topic coverage tends to be at a shallower level focusing on learning simple facts and routine procedures. While, through the efforts of the NCTM and many state education agencies, there is some effort at problem solving (at least in the form of simple word problems) very little attention is paid to truly demanding expectations of students. It is rare to find more involved activities and projects. It is rare to find materials that demand less routine problem solving or that truly demand mathematical reasoning and thinking. This is not true in the countries that achieved at a higher level in TIMSS.

There are at least three problems with demanding more from students for any given mathematics topic. First, doing more demanding things takes time and time is at a premium in US mathematics curricula because so many topics are required to be covered in state and local standards. Second, **doing more demanding activities requires material that simply is not in US textbooks. US textbooks are market driven and reflect our "mile wide and inch deep" perspective by covering many topics with little demanding work in any one of them.** This requires any teacher who would go deeper into content to demand more from students to supplement textbooks. This is very difficult for individual teachers, especially those that may work in more isolated settings as would seem the case in rural education. Third, doing more requires more understanding on the part of the teacher. When the teacher must move beyond the textbook as a default curriculum, more burdens are placed on the training of the individual teacher and on her or his knowledge of what supplemental materials and approaches are available. Again, this would seem to be a problem that would be made worse by a situation in which it is hard to call regularly on the advice and support of colleagues as would seem to be the case in teaching mathematics in rural settings. Pursuing "best practices" in this context seems to create special problems.

Interpret standards carefully

When one looks at typical content standards in the US, especially those patterned carefully after the NCTM Standards, one sees a demand to cover a wide variety of contents in each grade. These standards typically reflect the "mile wide and inch deep" approach, even when the standards (such as the NCTM Standards) call for more demanding content) because they demand the "mile wide" part of US typical practice and this seems to limit US practice to being an "inch deep." When these content standards are mandated by a state and especially if they are linked to high stakes state assessments used for accountability, they move significant change beyond the power of individual teachers.

A careful interpretation of standards can lead to reorganization so that more focused coverage is given to a sequence of key topics over the grades with less review. This would be a move towards "best practices". However, this move seems most often beyond the power of individual teachers, especially in isolated settings where theirs may be a single voice for change that must carry weight with principals and parents in a situation that can look as if they are trying to avoid accountability. To truly pursue "best practices" requires that teachers not be left as isolated voices. They must receive encouragement and support to pursue changes. There must be higher leverage advocacy to reorganize and re-focus many state standards to allow pursuit of better practice. The question here is now what "best practice" is but, rather, how to attain it.

Use textbooks selectively

US textbooks are market driven and inclusive. They include coverage of more topics than those of almost any other country at almost every other grade other than in high school do. In high school US mathematics education is organized into single area courses (algebra, geometry, etc.) and this is almost unprecedented around the world since the norm in integrated mathematics courses that continue to cover some of several major topics (some algebra, some geometry, etc.). This is not to be taken as implying that internationally high school textbooks become a mile wide and an inch deep as the books for earlier grades are in the US. They may cover several topics but in more depth and never as many as are covered in US textbooks. However, those several topics come from different areas of mathematics and this is not the case in the US.

Further, US textbooks are organized into many small segments moving from topic area to topic area with little continuity and using very low-level, brief activities. One might liken the mathematics curriculum as it appears in US textbooks to the academic equivalent of "channel surfing" or "surfing the World-Wide Web." It is hard to teach an extended, in-depth lesson on one topic using a US mathematics textbook without supplements.

This creates a special burden in achieving "best practices." Textbooks must be used selectively to provide on a small scale more focused in-depth coverage of topics and coverage that demands more from students. This requires that someone provide guidance on how to use the textbooks that are mandated for use in a particular school setting. The choice of textbooks is beyond the province of individual teachers in most cases. Mechanisms are needed to aid them in using textbooks selectively and in supplementing them with more demanding, focused material. This again would seem to be a particular problem in rural settings if individual teachers must work in relative isolation.

Make instruction more coherent

In a given class period US mathematics teachers typically make use of an instructional routine that involves a larger number of activities that are shorter term than is true for mathematics teachers from the higher achieving countries in TIMSS. Extensive use is made of seatwork and beginning homework in class. None of these things - many activities, brief activities, excessive seatwork, and doing homework in class - are typical of mathematics teaching in higher achieving countries and cannot be considered "best practices". Instead, **teaching needs to move to fewer but more demanding activities in a class period integrated around a topic that is pursued for more than a single period and with a variety of related activities.** Extensive review or seatwork should be eliminated in favor of more time on new material or going in-depth into topics. Class time needs to be used for activities that require group participation and teacher involvement rather than teacher supervision of individual efforts (for example, beginning homework).

US mathematics teachers are not typically trained to see more coherent, focused instruction as a more effective approach. US teacher instructional patterns are typically set around the tenets of the "direct instruction" approach that emphasizes a variety of short activities, planned transitions, etc. This is seen as essential to maintaining student attention and to effective classroom management. In this context it is both a demand on the individual teacher and a gamble to rely on being able to engage students in demanding content that will avoid classroom management problems and keep their attention. However, that seems exactly what is required for "best practice". Again teachers already in service seem to need additional support, models, professional development activities, materials, and so on, that would aid in moving towards best practices in this area. This again seems a particular problem for teachers in a rural setting in which they must work in relative isolation and with little external support.

Conclusion

One common thread in the above depiction of "best practices" seems to be that most of these practices address systemic changes. Most involve different practices that are hard for individual teachers to achieve on their own, especially those that must work in relative isolation. However, the serious flaws that must be remedied to achieve "best practices" in mathematics education are systemic and not the problems of individual teachers. **Achieving best practices requires systemic solutions and systemic support.** Since teachers in rural settings cannot achieve such solutions and support on their own, it would seem that "best practice" requires that others put such systemic support systems in place. This may be a reasonable activity for rural systemic initiatives and an area for developing field-based action research on what works.

Learning Technology: Contextual Issues Prepared for the Appalachian Rural Systemic Initiative

"What does it mean to be educated and ready to thrive in a digital society?

With the accelerating change of the last decade, the answer to that question has been a moving target. While schools are far from answering the question and establishing a school system that ensures every student will 'thrive in today's digital society," the solution is evolving. The solution will only be attained by pursuing the right questions:

- What value does technology bring to learning?
- Will we know it (the value) when we see it?
- Should the metrics of success in learning change and/or be extended to include 21st century skills?
- Why does technology 'work' in some classrooms and some schools-and not others?
- What defines the digital divide and how can we work to bridge that gap?
- How can schools better track, gauge, and report their progress with technology?

Growing Up Digital

"Students are natives to cyberspace, where the rest of us are immigrants."

-Douglas Ruskoff, Playing the Future, 1996

Today's children are "growing up digital." Their view of the world is quite different from that of adults. They are growing up with unprecedented access to information, people, and ideas-across highly interactive media. In his book, Growing Up Digital, Don Tapscott (1998) suggests that it is precisely this real-time, webbed interactivity that has spurred societal changes in ways prior technologies did not.

Since 1994, when the Internet rose from obscurity to popularity due to the World Wide Web, over 116 million Americans (44%) have logged on. Americans now use the Internet for business transactions, shopping, entertainment, information searches, communication, and, to some extent, learning. In January 2001, the Web-based Education Congressional Committee reported, "The World Wide Web is bringing rapid and radical change into our lives-from the wonderfully beneficial to the terrifying difficult" (Kerry & Isakson, 2001).

Unsophisticated Use Prevails in Schools

Students report that the digital revolution is happening in their homes-not in schools. In a recent national poll 61 percent of students said that their home computers were of better quality than those they use at school. In addition, a full 50 percent of students reported computer use at zero to one hour per week while 57 percent reported at least five hours per week in computer use at home.[i]

SOURCE: Education Week/MDR/Harris Interactive Poll of Students and Technology, 2001

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Cheryl Lemke is the CEO of the Metiri Group, a learning technology consulting firm based in Los Angeles, California. With more than 20 years experience in public education, she has held positions as the state Technology Director in Washington State, the Associate Superintendent for Learning Technology for the Illinois State Board of Education and the Executive Director for the Milken Exchange on Education Technology. The Metiri Group clientele includes U.S. Congressional Committees, WorldCom Foundation, IBM, Microsoft, North Central Regional Educational Laboratory, state education agencies, and school districts. Lemke earned her Master's in Education at the University of Washington in Education Technology and her Bachelor's of Science in Mathematics from Western Michigan University. She taught high school mathematics for nine years in an inner city school in Michigan and a logging community in Washington State. lemke has been honored by the technology professional organizations in Washington and Illinois with their Educator of the Year awards. She is a regular author of journal articles and presenter at national, regional, and state technology conferences.

While three-quarters of teachers are using technology on a daily basis, such use is not very sophisticated. In fact, students report that only about half of their teachers help them visualize new concepts using technology. It should come as no surprise that, while 9 out of 10 students believe they that knowledge about computers is extremely or very important to their future careers, only about 40 percent believed computers to be important to learning.[ii]

Technology is exerting both a push and a pull on educational practices. Both promise to influence, in time, the way children learn, teachers teach, and schools are managed. But one would be wise not to hold one's breath waiting-computers were introduced into K-12 classrooms over twenty years ago. Yet, to date, schools have not come close to matching the dramatic shifts in the economy, communication, transportation, and medicine, that most other fields have experienced due to technology.

The Push from the Digital Age

The "push" by the technology for change in schools comes from business leaders, parents, community, and even the students themselves. This is a digital age-a global knowledge-based society. The economic health of the country is due in large part to e-commerce and growth in information technology. The 21st Century Workforce Commission,[iii] reported the following statistics in June of 2000:

- By 2006, nearly half of all U.S. workers will be employed in industries that produce or intensively use information technology products and services. There will be a premium on American workers who are able to read and understand complex materials, think analytically, and use technology efficiently.
- The Bureau of Labor and Statistics projects that, between 1998 and 2008, more than two million new skilled information technology workers will be needed to fill newly created jobs and to replace information workers leaving the field.

With a significant gap between the skills of today's worker and the growing need for information technology skills, the business community is calling for increased preparation in proficiencies for the 21st century. The CEO Forum[iv] recently identified the 21st Skill Set developed by the North Central Regional Educational Laboratory as critical for U.S. Economic viability. Those skills fall into the four categories of Digital Age Literacy, Inventive Thinking, Effective Communication, and High Productivity. The education community generally acknowledges that these skills should be incorporated into the K-12 system but has not done so to date. High stakes testing is based on academic standards that vary considerably state to state and do not, in general, address many of these skills. In many cases these skills have been found difficult and/or expensive to measure-so in cases where they are addressed they are often not measured. Note: Educational Testing Service and the National Assessment of Educational Progress are working on prototypes to use technology to conduct wide scale assessments of more difficult concepts such as inquiry-based science.

Another push for change in teaching and learning comes from the medical field. The technology itself is providing new insights into the working of the human mind. *How People Learn*, published in 1999 by the National Research Council is groundbreaking in that it addresses the convergence of brain research, cognitive learning theory, and technology. The authors discuss the medical breakthroughs in imaging of the brain that have allowed scientists to understand more fully how people think and learn. The publication lists five ways in which technology adds value to learning:

- real-world contexts for learning,
- connections to outside experts,
- visualization and analysis tools,
- scaffolds for problem solving, and
- opportunities for feedback, reflection, and revision.[v]

Practitioners agree with those findings. The Department of Education's fall 2000 conference, "Technology in Schools: Measuring the Impact and Shaping the Future," engaged classroom teachers, educational administrators, researchers, and policy leaders in a working conference. Discussion forums, white papers, and expert panels concluded that:

- Breakthroughs in technology have advanced what is known about how children think and learn.

21st CENTURY SKILLS

1. Digital Age Literacy	2. Inventive Thinking	3. Effective Communication	4. High Productivity
• Basic, Scientific, and Technological Literacy	• Adaptability/Managing Complexity	• Teaming, Collaboration, and Interpersonal Skills	• Prioritizing, Planning, and Managing for Results
• Visual and information Literacy	• Curiosity, Creativity, and Risk Taking	• Personal and Social Responsibility	• Effective Use of Real-World Tools
• Cultural Literacy and Global Awareness	• Higher Order Thinking and Sound Reasoning	• Interactive Communication	• Relevant, High Quality Products

- Research shows that, under the right conditions, technology advances children's academic achievement.
- Technology's tremendous influence on society has changed what children need to know and be able to do to be successful today.
- Emerging technologies can and should be used to more accurately assess what and why children are or are not learning.

Despite the strong 'push' from a digital society to change, the K-12 sector has yet to break through the glass ceiling and begin using technology as the powerful learning tool it has the potential to be-under the right conditions.

A Pull from the Digital Age

There is also a strong pull toward technology-an incentive for educators to improve student performance and achievement of state standards through the use of technology. In most cases the evidence sought by educators and policymakers is increased standardized test scores. Research shows that test scores can be improved when technology is used under the right conditions.[vi] [vii] The type of technology use shown to improve scores varies from the integrated learning systems and computer assisted instruction used in West Virginia to raise mathematics and language arts scores by 11 percent viii to the use of visualization tools in science demonstrated by UC Berkeley to increase students' understanding of science (e.g., deepening students understanding of the difference between heat and temperature when science probes and on screen visualization tools were used).[ix]

Another clear example of this is the use of FastForward, by Scientific Learning which demonstrates that when a learning deficit is carefully diagnosed and a technology invention carefully prescribed, student gains can be achieved quickly.[x] Dr. Marci Linn and colleagues from UC Berkeley have produced groundbreaking work in which the most effective technology-based resources in mathematics and science were identified for K-8 mathematics and science,[xi] high school science,[xii] and high school mathematics.[xiii] In each report **readers are cautioned to not consider technology a panacea but rather a tool through which to augment, enhance, and customize science and mathematics learning;** and a clear necessity if students are to be prepared for the age in which they live.

While most proponents of learning technology do not find the raising of standardized test scores to be the most compelling use of technology in schools, they do agree that technology, when prescribed carefully, can individualize learning so as to increase fluency; present concepts through visualization, simulations, and exploratory learning; and thus, contribute to the raising of standardized test scores.

The challenge is that not all applications of the technology result in such increases in scores. The authors of two frameworks for effective technology use, the Seven Dimensions for Gauging Progress[xiv] and enGauge[xv], show that the impact of technology on learning depends on use under the right conditions. Used inappropriately, by educators who are not fully prepared, technology can actually be a deterrent to learning. [xvi]

The enGauge model identifies a range of use model that educators should consider when assessing the appropriateness of technology use with students. That model suggests that the impact of using technology with students is directly influenced by the context-a combination of the instructional approach as well as the complexity and authenticity of the learning activity.

Range of Use (c) NCREL, enGauge

A Digital Divide

The range of use model shows various ways in which technology can be used in support of student learning. Unfortunately, many students, especially those disadvantaged, minority students do not experience the full range of uses described in that model.

The Department of Commerce report, Falling Through the Net, released in October 2000, reports that:

- U.S. Households with Internet Access soared to a record high of 41.5% in August 2000.
- More than 116.5 million Americans were online at some location as of August 2000.
- This rapid uptake of technology use is occurring among most groups of Americans regardless of income, education, race or ethnicity, location, age, or gender.

The report clearly states that Internet access is "no longer a luxury." If the Digital Divide were defined strictly in terms of Internet access and computer ownership, current statistics would indicate that digital inclusion would be a realizable goal. But that chasm is deeper than just access-it also represents differences in the capacity to use these tools efficiently, effectively, and innovatively. Access is only the first step toward equity-true equity will require high levels of technology proficiency to ensure broader, meaningful, innovative uses of technology by all segments of the population.

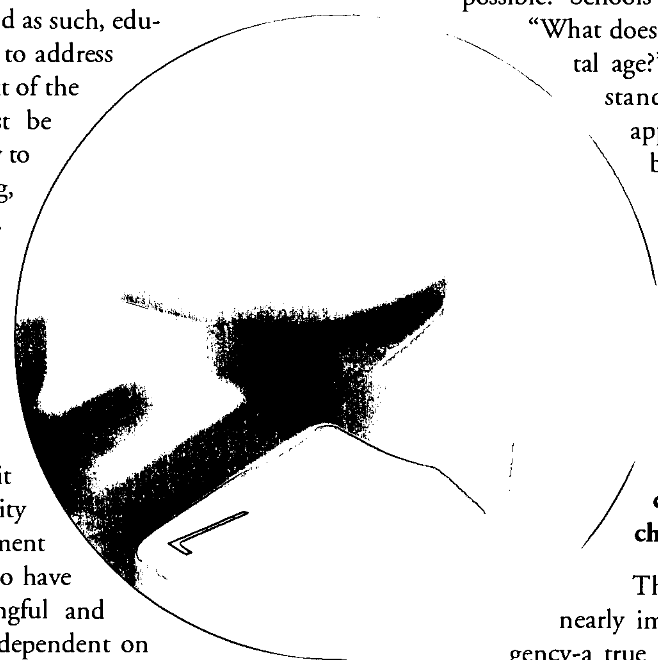
The Conditions Essential to Effective Use

Clearly, technology can and does add value to learning when used appropriately. The enGauge model[xvii] suggests that six conditions are essential to the effective use of technology in schools. When ignored these conditions can represent barriers to effective use.

Forward-Thinking, Shared Vision. A forward-looking vision for digital age learning should be driving decision-making in schools. The lack of such a vision is the number one reason for ineffective use of technology in schools. Teachers don't have new visions for how emerging technologies can enrich, deepen, and extend teaching and learning.

Effective Practice with Technology in Teaching and Learning. Learning is enhanced through authenticity, alignment of curriculum, instruction and assessment, a range of technology use, and relevance of material to the learner. While technology is a component of that mix, **the effective use of technology requires a culture of learning that values the individual and is open to innovation and creativity**. It also requires an assessment system that honors and rewards the achievement of 21st century skills that result from such applications.

Educator Proficiency with Effective Uses of Technology. The educator is key, and as such, educators must be adequately prepared to address 21st century skills within the context of the academic standards. They must be familiar enough with the technology to use it as an everyday tool in teaching, learning, and professional practice. Their teaching philosophy is also critical to successful use across a range of applications.



Digital Age Equity. The access gap inside schools is closing-but when one group of students has access 24x7 and another doesn't, it creates a divide. The issue of equity goes beyond simple access to equipment and bandwidth. It is not enough to have access-that access must be meaningful and purposeful. The quality of use is dependent on the proficiency of educators to use technology effectively.

Robust Access-Anywhere, Anytime. While schools have made great strides over the past few years in wiring classrooms and deploying workstations, many schools still have outdated equipment and insufficient access to the Internet. This creates a barrier to effective use.

Systems and Leadership. The latest equipment and robust bandwidth, combined with the most informed teacher is no match to the barrier of outdated rules, regulations, and bureaucracies. If technology is to be used effectively schools must evolve into high-performance, high-tech systems that encourage innovative, relevant, technology-supported learning.

Few schools have paid attention to all of these conditions. While most have made strides with infrastructure, they have yet to turn their attention and address all six conditions-a necessity if all children and youth are to achieve

Conclusions

Times change, and in today's digital age, accelerating change has been the norm. The typical school is not able to keep pace with the tremendous depth, breadth, and rate of this change. Educational leaders are expected to make multi-million dollar decisions about online/virtual learning, telecommunications infrastructure, training programs, student Internet access, Intranets, and software in volatile times of shorter and shorter obsolescence cycles, short-lived dotcom service providers, and a lack of clarity as to the real impact of technology on learning.

Technology brings new approaches to learning never before possible. Schools need to be asking the question: "What does it mean to be educated in the digital age?" Once that question is answered, standards, curriculum, instructional approaches, and assessments need to be revisited and aligned. But the solution will not be found merely in long-range plans or extensive curriculum redesign. It will require shifts in thinking, decision-making, and leadership. **Schools can only become high-tech, high-performance systems if they become organizations of people, guided by common principles, who learn, reflect, and change daily.**

The complexity of the times makes it nearly impossible to plan for every contingency-a true system, like an ecosystem, realigns itself as conditions and contexts change. And therein lies the formula for education's bridge into a high-tech, high-performance system-creating a healthy, interactive, vibrant, open system that constantly evolves toward the vision. To do so, stakeholders must:

- Set a compelling vision for learning in a digital age and ensure that the vision is shared,
- Build the capacity of the system to think and act smarter through increased knowledge and informed decision-making,
- Establish a culture that links and interconnects all parts of the system within a context of openness to innovation and change,
- Focus that culture on aligning the components of the system-policy, research and practice-to the vision, and
- Hold the various components of the system accountable for progress toward the vision, identifying indicators of success and tracking and reporting progress.

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The Rural Condition In Contemporary Appalachia

I am always amazed at how little Americans know about rural America; how little we really know about Appalachia - despite the fact that most of history is deeply connected to our rural character and many of us were raised in rural communities. The same is true of Appalachia. Appalachia is one of the most studied and most media popular places in the United States. Because most of the story telling about rural America and about Appalachia is done by urban-based journalists and scholars, our image of rural society continues to be shaped by old urban stereotypes and elite assumptions. The truth is that Appalachia and rural America today are places of complexity and old images simply do not apply. The truth is that rural America and Rural Appalachia are not defined by geography or even by residence - they are not simply non-metropolitan areas - but are constituted by a particular set of cultural relationships and experiences and are characterized today by considerable diversity and complexity.

Ron Eller

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Appalachia today is:

1. Diverse - characterized by diversity in its class structure, its economy, and its demography
   a. New class system shaped by new generation of professionals
   b. New urban vs. rural differences within Appalachia
   c. Diversity in ethnic mix (more Asians and Hispanics)

   Kentucky Governor, Paul Patton, likes to talk about "the New Appalachia," as one of greater prosperity, better health care, better housing, connected to the mainstream of America - that Appalachia very much exists
2. Old Appalachia - New Appalachia (Two Appalachia's)
   a. New Appalachia of shopping centers, malls, fast food chains, WalMarts and golf Courses
   b. An Appalachia still tied to agriculture, mining, and light manufacturing
   c. An Appalachia that is still poor (ARC's 111 distressed counties); characterized by low incomes, greater dependency on transfer payments, higher rates of unemployment, poor housing and major health problems
   d. An Appalachia suffering continued population decline as seen by rising elderly population, declining school-age populations, pushing schools to close and consolidate and systems to lose money for the education of those that remain
3. Lower Levels of Educational Attainment
   a. Higher levels of adult illiteracy
   b. Higher high school drop out rates
   c. Fewer people with any post secondary training
   d. Low levels of education tend to be concentrated in com-

munities and to run in families (a cycle which is difficult to break with traditional individually oriented programs (adult literacy vs family literacy)

4. Poor Civic Infrastructure

   a. Poor quality of local government services

   b. Weak social institutions

   c. Limited leadership capacity and limited vision for future

Indeed, despite measurable progress in some areas, rural communities in Appalachia lag behind in most measures that we associate with success in the New Economy. Yet I am not one who thinks we ought to define Appalachia by its problems or to dwell on our deficits.

These same rural communities, these same distressed areas, have many assets. They are not the same places they were 30 years ago, and the old deficit model overlooks many strengths that these places bring to the new age.

Rural Assets

1. New Rural Technologies

   a. The digital age provides opportunities that were not there before; it has closed distances and opened access to whole new opportunities

   b. While the digital divide exists, the gap in digital infrastructure is not as great as it might be

   c. The new technologies provide opportunities for employment that free rural areas from a resource based economy — products, markets and consumers can be much farther apart and rural areas are no longer at a market disadvantage in e-commerce

   d. Increased services: opportunities for distance learning and virtual training and for more efficient delivery of human and social services

   e. Less isolated; because of the revolution in mass communications rural areas are part of the global society

   (TV, WEB, and wireless telecommunications have significantly reduced the isolation of rural areas everywhere)

2. New and Better Physical Infrastructure

   a. Highways

   b. Health care facilities

   c. Community colleges and branch campuses

   d. Consolidated high schools (better laboratories, classrooms, technologies, and libraries)

   We now have technology in every classroom and will soon have technology at every desk

3. Family system and Community loyalty

   Family and community loyalties are still strong in rural America over other priorities.

   These values can be a strength for the future if we know how to use them to encourage education and economic development. Most rural people want to remain and live in their communities. They want better health care, better housing, better education, and meaningful work to strengthen their families. Rural culture tells them to be proud of who they are and that they have a responsibility to each other. Values (though not always valued in modern mass society) are values that can be used to build wealth and improve life (e.g. native Americans).

4. Rural Populations tend to be "centered" and focused

   a. Are less likely to go with the crowd; to go with just any national fade or personal convenience - and the center of their world, despite years of consolidation is often still the school.

   b. School still tends to be the place where local people meet, where students and parents are still more likely to participate in extracurricular and community based activities and where local accomplishments can be shared and celebrated.

   c. Schools may be the closest thing we have in rural America to the "civic" places where social scientists tell us democracy grows and where new ideas for development have the potential to sprout and mature.

5. Communities of Hope

   Rural Appalachia, despite the popular image, are not places of despair and fatalism, but are places filled with people who work hard, value working together and have hope that their lives will improve. Their vision for the future may be slightly different from that found in many urban settings, but they look to the new age with a great deal of optimism. For they know that rural America will survive the New Economy and indeed could prosper from it, for they also know that rural America is not a place out of time but a way of looking at life in time. They are, as Appalachian poet James Still put it "strangers on familiar slopes." Unlike too many urban scholars who think we know it all, rural people know better.

Implications for Education

How can we ride the river of the new century? How can we change with the times, take advantage of our strengths, and overcome our deficits as rural Appalachia enters the new digital age? How can we as educators guide how students so they can be successful in the new America without losing the best of the rural world?

1. We must place greater emphasis throughout the curriculum on digital skills and on science and technologies; not because the jobs of the future demand it, but because living in the 21st century and protecting the rural way of life will demand it as well.

2. We must integrate the family more effectively into the education process than was the case in the 20th century (when emphasis was on individual learning). In rural areas, educating the individual may mean educating the whole family; this may mean redefining the classroom, redefining the curriculum to engage the whole family.

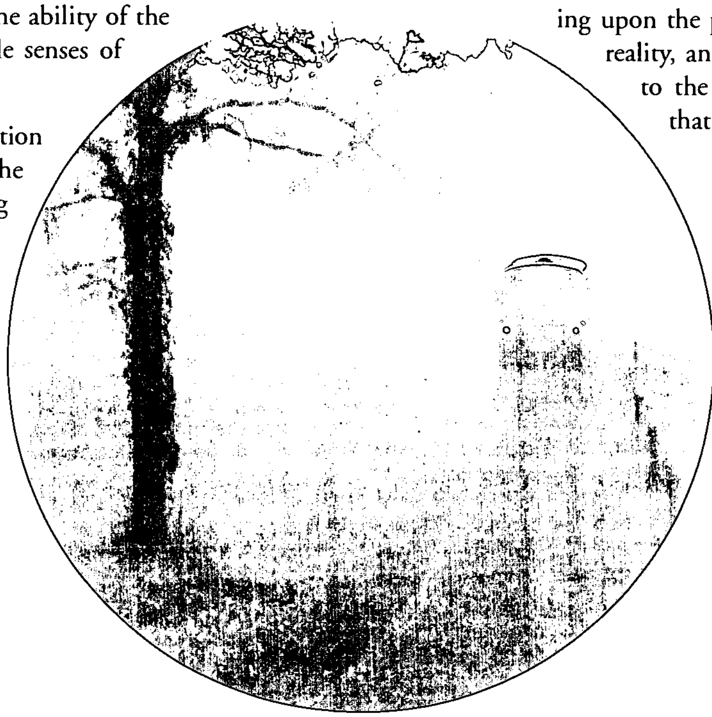
   We as teachers need to learn how to use the family as a resource in education just as Appalachian doctors are learning to use the family as a medical resource to promote individual healing.

3. Gender has now become a critical educational issue. Not only do we need to encourage more women to enter the sciences but we need to address the problem of the displacement of young males. We have a lost generation of displaced mountain males today. We need models of male success in rural areas, and the ability of the curriculum to speak to male senses of identity.

4. We need greater collaboration with institutions outside of the school if we are to bring together resources and information for rural children to succeed in the future: collaboration with hospitals, local industries, and local civic organizations to provide everything from lab equipment to funds for field trips and professional development. We must redefine education as a community responsibility rather than as the realm only of a group of professionals as the urban model of education has taught us.

5. Education in rural communities must increasingly be "place-based," rooted in the culture and experiences of the local place. In rural areas where people have traditionally learned things in a "hands-on" fashion through experimentation and the practical application of knowledge rather than through abstract learning and memorization. This may require redefining the classroom to include the community and the nearby ecosystem and redefining pedagogy as more student centered and applied learning rather than as teacher centered instruction.

The development of the new economy has been accompanied by vast and rapid changes in most facets of our lives. The *River of Earth* seems to be flowing even more rapidly today. As former Secretary of Labor Robert Reich states in his most recent book, *The Future of Success*, "there is no turning back to the old jobs and the old securities, to the old families, and the old communities." The nature of work and requisite job skills are changing everywhere, and rural areas are no exception. More than ever before rural prosperity depends on increasing rural people's access to educational opportunities. Let us hope that those opportunities can be provided in a way that validates rural life and culture and takes us into the 21st century by building upon the particular way that we understand reality, and without losing that relationship to the natural world and to each other that we value.



Why Research on Science and Mathematics Education in Rural Schools is Important Or The Mean is the Wrong Message

Introduction

A recent story in our local paper reported the results of a study suggesting local schools were failing and not living up to the promise of Kentucky's educational reform because there were large differences between the performance of schools with high proportions of poor students and those with low proportions of poor students. This not unusual finding, variously reported as a difference between the average test scores for "rich" schools versus "poor" schools or average differences between "rich" students and "poor" students, is now labeled the achievement gap. There is also an achievement gap between white students and minority students, where it is usually African Americans who are considered the minority.

Educational research, unfortunately, often focuses on finding statistical differences between overall means or averages. Most media reports of results of such research routinely give those differences and little else. Both are committing the cardinal sin of reporting centers of the data without reporting how spread out the data are. They report means and mean differences as though that is all one needs to know in order to understand the findings of the research and what the implications might be for educational practices. **Never a center without a spread** I tell my students and I hope tonight to demonstrate why that is a good axiom and how it might be related to research focused on rural schools.

Some Data

Figure 1(pg. 46) presents some test score results from the Kentucky assessment for 4th grade students from "some "county. The first thing to look at is the table containing the centers. There are two groups, one contains over 1800 students the other over 500. For the larger of the two groups the mean on a scale that goes from 10 to 100 is about 59; the smaller group has a mean of 42. This is an achievement gap of 17 points and would appear to be rather large.

The other parts of Figure 1 show the data so one can get a sense of the spread and distributions of scores. On the left is a box and whiskers plot1 that shows the so-called achievement gap (the middle score for group 1 is higher than the middle score for group 2) but also how the scores overlap. The outliers of Group 2, for example, score at the highest levels. Fifty percent of the Group 2 scores are below 40 but so are about 25% of the Group 1 scores. More than 50% of the Group 1 scores are above 50 but so are more than 25% of the Group 2 scores. The point is that the mean differences can be misleading because otherwise reasonable persons can be lead to believe that average differences mean that *all* persons in one group score higher than *all* of the persons in another group.

The dotplot on the right portrays each of the scores. Notice how much the distributions overlap. But more important, notice that because Group 1 contains so many more students,

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there are more Group 1 students below the Group 2 mean than there are Group 2 students below the Group 2 mean. In fact, in every part of the distribution one finds more Group 1 than Group 2 students.

The general point I would make about the two pictures in Figure 1 is that if the issue is higher test scores, there is more work to be done in Group 1 than in Group 2. More important, however, is that focusing on mean differences and nothing else is likely to create stereotypes about the groups and make the issue appear to be low performance in Group 2. If there is an issue related to low performance, it is an issue about students not about group averages. And, more students in Group 1 than Group 2 are experiencing the problem.

Looking at Schools

Although the pictures in Figure 1 do a better job of portraying the data, they, too, are limited. Those scores are of students in a county. But students do not attend counties they attend schools. Figure 2 (pg. 47) contains boxplots for six elementary schools in this county. Notice how varied the patterns of differences are. The school represented in the bottom right picture is a school where there are huge differences between the groups. The highest scorers in Group 2 are about at the 50th percentile for Group 1. But look at the boxplots in the upper right of Figure 2. Group 2 scores are higher than Group 1 scores in that picture. The top left picture shows how much less varied the scores for Group 2 re in that school. The middle left picture is interesting because the number of students in Group 2 in that school is so small that there are not enough data to draw the whiskers. Despite their small numbers students in Group 2 have high scores, often higher than the majority of scores of Group 1 in the other schools.

I hope that we have moved beyond the achievement gap of 17 points and to a place where interesting questions can be raised. A first question, of course, is what accounts for these different pictures? Are there policies related to how students are allocated to schools that produce the differences? Do teachers in the different schools treat students in the two Groups differently? Is there some combination of policy and pedagogy, mathematics and science curriculum, that accounts for the differences?

Another set of questions addresses what students experience in the schools. If you were a member of Group 2, which school would you rather attend? Why? If you were a member of Group 1, which school would you rather attend? Why? If the answers to those two questions are not the same, why not?

Another Way to Look at Spreads

Unfortunately my data set does not contain classroom identifications. I would like to look, of course, at each classroom in each school and see what those distributions of scores look like and then start asking questions about the different patterns that [illegible] would find.

But I do want to talk about classroom differences so I will take another data set and make some slightly different points. Figure 3 (pg. 48) portrays data from the Second International Mathematics Study2 for grade eight students in the United States and grade seven students in Japan.

The pictures are the results of a statistical technique called variance decomposition that seeks to describe, in this case, a set of scores in terms of whether the variation is between students within classrooms, between classrooms with schools, or between schools. The areas of the pie charts are proportional to the total variation in the scores. The pictures allow one to compare the variance components in Japan with those in the United States in terms of what I call status - test scores at one time point, in this case a pretest at the beginning of the school year. A second comparison is of the components of status in the United States versus the components of growth in the United States. Growth is the difference between a posttest at the end of the school year and the pretest.

It should come as a surprise to you that the area of Japan's status pie is larger than the comparable U.S. status pie. (A way to think about this difference is that if test scores were a 100-meter dash the difference between the fastest and slowest runner in Japan is bigger than the difference between the fastest and slowest runner in the United States.) Yes, as the media reports Japan's average score is quite high and among the highest internationally. But, the spread of Japanese scores is among the highest internationally, too. Does that say something about practices in Japanese schools?

The components of the pies (how does one partition the area, the spreads) reflect the structure of schools and schooling in the two systems. Notice that almost all of the variation in Japan is between student differences and there are small differences between schools and classrooms. In the United States the biggest component is between classrooms. This reflects tracking of students into different types of mathematics courses in U.S. schools in the eighth grade. Japan has a common mathematics curriculum for all students. The United States differentiates the curriculum so different students are exposed to different kinds of mathematics. Do these practices lead to different levels of achievement in the two systems? Yes.

I included the growth pie in the United States for a couple of reasons. First, notice that the area of the growth pie is smaller than the area of the status pie. There is less variation to explain when one deals with growth. Second, the components of the growth pie are very different from the components of the status pie. The great majority of the variation in growth is between students; the between classroom component has shrunk substantially.

Reports of mean differences between types of schools or types of students typically are reports of status not growth measures. It can be argued, however, that schools should be judged in terms of their impact on students or the amount of growth that occurs.

But, and this is an important point, the concomitants or correlates of achievement status are different from those of achievement growth. In general, the background characteristics of students are more highly correlated with status than with growth. Effective teaching practices are more highly correlated with growth than with status. Concretely, if one looked at the differences between groups in terms of growth rather than status, those differences would be much smaller for the growth measures. And, if one started to look at the spreads of growth between students and classrooms, those pictures would be very different than one gets with status measures. How to understand the differences between schools and classrooms in terms of growth and spreads is what a researcher should focus on.

And What About Rural Schools

I know this was a long-winded introduction to research with and about rural schools. Yet, it is a necessary prelude because I think those who investigate issues surrounding rural schools are in a position to answer some very pertinent educational questions. And, they will be rewarded if they approach the task in terms of seeking answers to questions about spreads, not centers. These significant questions, I believe, are about small schools, small classrooms, and the relationships among background characteristics of students and their performance in rural schools.

Small Schools

Not all rural schools are small schools. But, I think I am correct in saying that many of the researchers and much of the research about small schools have come from investigators who are interested, too, in rural schools. So I want to ask them to do more research.

I remember reading the Barker and Gump book, Big School, Small School as a graduate student and being convinced then that small schools on the average are better than large schools. Notice, however, that I fell into the centers trap. I think the evidence about small schools, if one thinks about spreads, would suggest that some small schools are better than large schools and others are worse. **A set of research questions about differences among small schools, what makes one small school better than another, and on what important dimensions are they better seems to me to be an interesting set of research questions.** I would like to know, for instance, if a small school is central to a community either geographically, symbolically, or in some other way, does that make it a superior small school. I would like to know how to explain differences in small schools that produce graduates who fare well in say, higher education, compared to graduates who do not fare so well. I would like to know something about the conditions in which teachers work in strong versus weak small schools and how those conditions are related to what teachers do and how students grow. I would like to know about the mathematics and science curriculum in the strong versus weak schools. And, I would like to know something about what teachers do with and about the curriculum. (Note: persons in large schools can ask and try to answer the same questions. I think, however, a first question is how to make large schools smaller.)

Perhaps persons already know the answers to these questions. I know, however, I was surprised by the results of a study of a graduate student in our department who looked at differences between rural schools that did better than expected on the Kentucky assessment versus those who did less well than would be expected. She found that variables such as degrees possessed by the teachers and their grade point averages were not related to the differences between schools. What was related to those differences, however, was the proportion of teachers who attended the school at which they were now teaching. Successful schools had higher proportions of such teachers than did the unsuccessful ones. There was a pattern of these teachers having left their school, gone to a regional university and then returning. Perhaps nepotism is good!

Small Classes

I am under the impression that rural schools (not all of course) are often doubly blessed by being both small and having classes with, relatively speaking, small numbers of students in the classes. This for me is another perfect research opportunity for those interested in rural schools.

The STARS experiment in Tennessee has documented, I believe, the superiority of small class sizes rather than large ones. The research I have read, however, compares the average performance of students who experienced small classes on a variety of variables to those averages for students in larger classes. Again it is a center without a spread. I would like to ask a set of questions about the differences between "good" small classrooms and "not so good" small classrooms. I would be particularly interested in two kinds of outcomes that have been reported to favor small class sizes: 1) the enduring effects of small classes (that is, students from small classes thrive after they leave that environment); and, 2) the smaller average test score differences between minority and majority students who have experienced small classes.

Suppose as a child I were really fortunate and had a really good mathematics or science teacher in a small classroom for my first four years of school. How big a difference would that make as I encounter more mathematics and science in subsequent years? What was good about that good teacher or what was different about that small class, or what was different about the mathematics and science that gave me such an advantage over those who were not in small classes or did not have that good teacher?

Likewise, suppose I was a minority student in a small class with a good teacher. What differences would appear as I continued my schooling? What were the characteristics of the teacher, the teaching, the content, the curriculum, or the class that made those differences? And, more important, are the answers to my questions about the efficacy of good teachers and small classes the same regardless of the types of students—whether I represent the majority or a minority? If not, why not?

Background Characteristics of Students

This brings me to my third general research issue. **I believe research on rural schools can help us understand better the relationships between backgrounds of students and their performance in schools.** As a corollary, research can inform us about the relationships among performance and student backgrounds between schools. That is, results of the research could paint a clearer picture of the effects of the background characteristics of a student body and the performance of a school. Why do schools with larger proportions of poor students do less well than schools with smaller proportions?

Kentucky has statewide testing that rewards or punishes schools based on whether or not schools increase their test scores. That accountability system imposes unreasonable expectations for more rapid growth for low scoring schools than high scoring schools. Typically the low scoring schools have higher proportions of students receiving free or reduced lunches (the proxy for being poor) than do higher scoring schools.

Periodically one of the educational interest groups in Kentucky trots out a school with large proportions of "poor" students that has high scores in some subject area included in the Kentucky testing program. (The research strategy that collects such results is suspect but I will leave that for another day.) What is interesting is that in most cases it is a rural school that fits the description of having both high scores and high numbers of students on free and reduced lunch. Why is the achievement gap narrower in some rural schools?

I would like to know whether the relationships between poverty and school outcomes are different for rural schools than, say, urban ones. If they are, I would like to know why. Is it because the proxy, free and reduced lunch, for poverty means a different thing in rural areas than urban ones? Is there something about rural schools or their contexts that provide more equal opportunities for students? Is there something about what goes on in rural schools that negates the effects of a student's background on her possibilities for being successful?

If there are differences, I think the answers to such questions are embedded in the spreads of scores of rural schools and classrooms in rural schools, not the centers. What are the characteristics of an effective school or its agenda that differentiates it from a less effective school when, at least superficially, the schools appear to be similar? If a rural school narrows the achievement gap, how does it do it?

Finally, I hope I have raised some interesting questions. I think a consortium like ARSI is the proper arena to begin to answer those questions. There are virtues in collaboration and virtues in looking systematically at important educational questions. Thank you and good luck.

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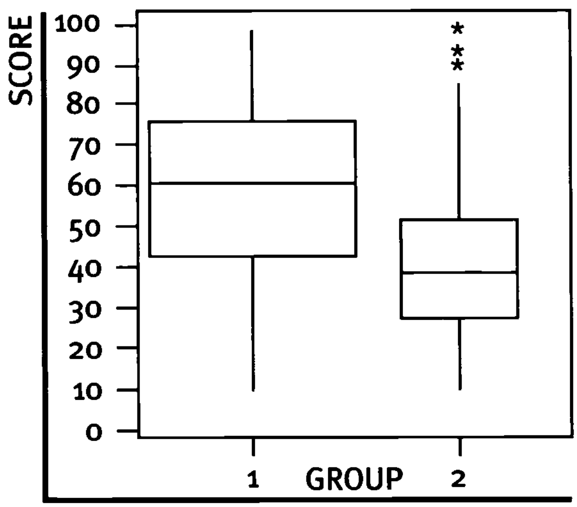
1. Boxplots represent the data in the following way: the centerline inside the box is the median or middle score; the top of the box is the 75th percentile and the bottom of the box is the 25th percentile - the box contains 50 percent of the cases. The whiskers cover about 95% of the cases while an asterisk represents outlying or extreme values. The widths of the boxplots are proportional to the size of the samples.

2. The results are similar for TIMSS, the Third International Mathematics and Science Study.

Figure 1.

Scores by group - 4th Grade Students

Variable	Group	N	N*	Mean
Score	1	1809	76	58.8
	2	547	33	41.2



Each dot represents up to 2 observations

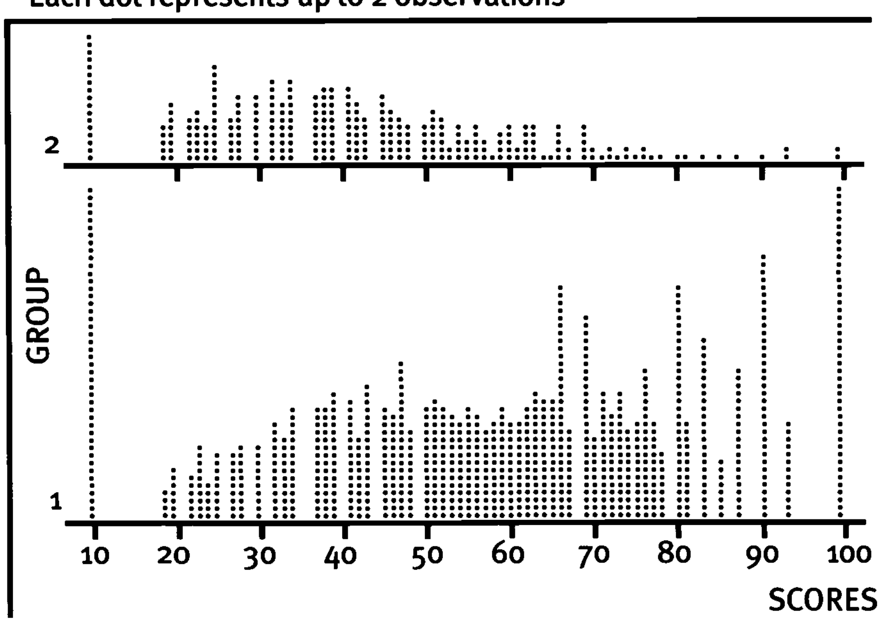


Figure 2.

Within school distributions - 4th Grade Students

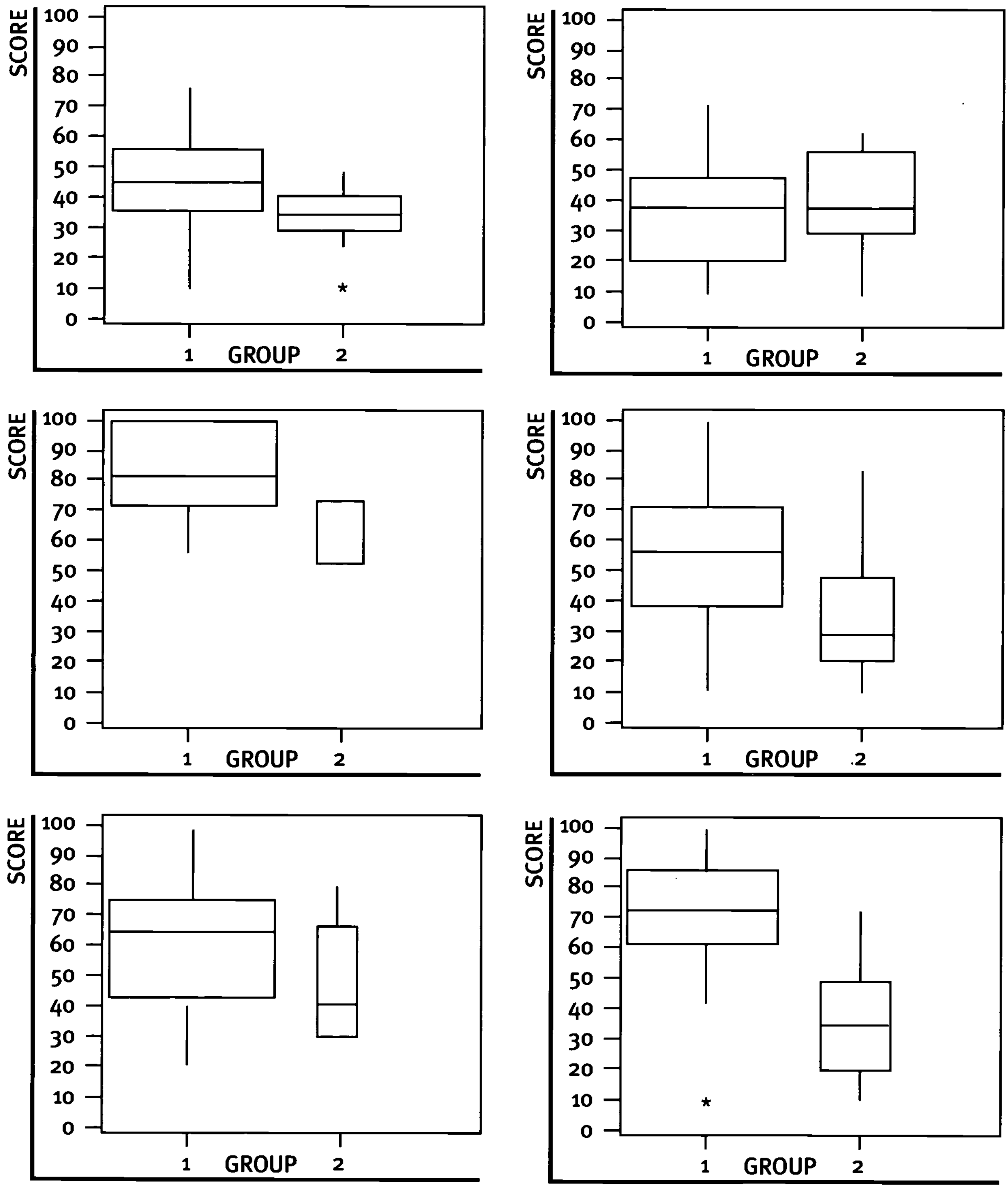
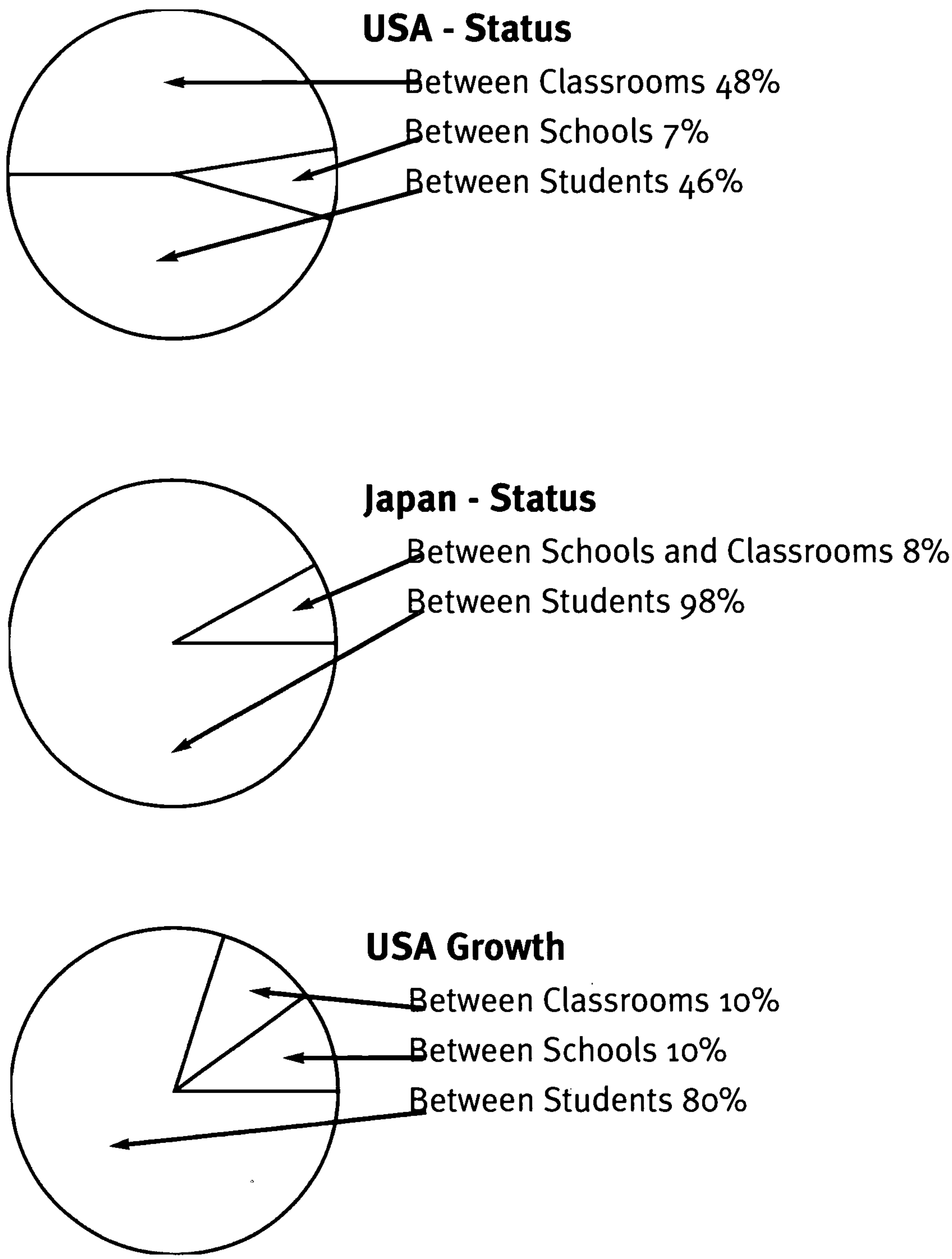


Figure 3.

Variance components of status and growth - 8th grade students



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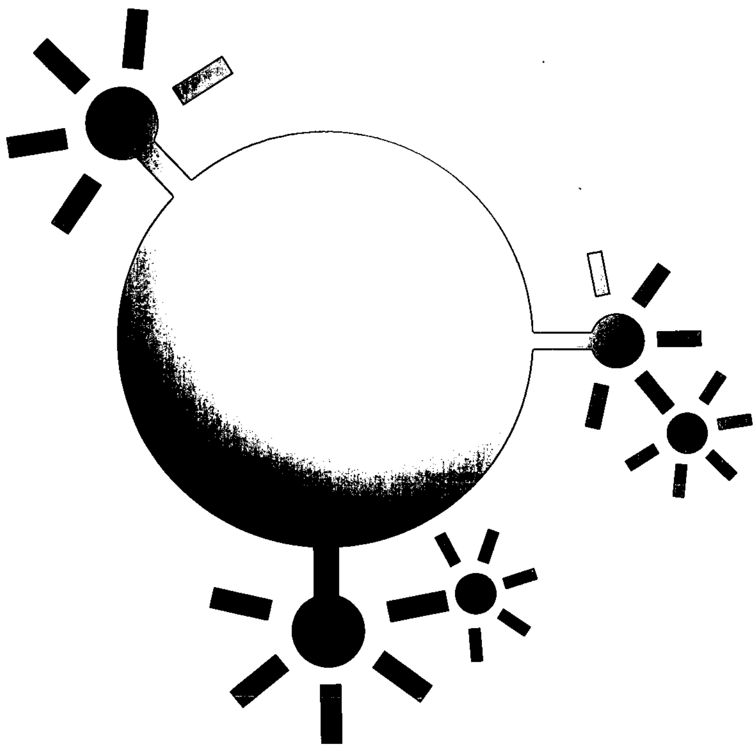

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