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ABSTRACT

This paper reviews the literature on mathematics education, rural education, and the effects of culture on mathematics teaching and learning with regard to the role of mathematics and mathematics education in central Appalachia. Studies of cultural differences between different countries, racial/ethnic groups, and genders suggest five general cultural factors affecting mathematics performance and dispositions: societal influences; parent attitudes, values, and beliefs; teacher attitudes, values, and beliefs; student perceptions and beliefs; and language. However, almost no studies have been conducted on the effects of rural culture on mathematics education, largely because rural culture is not clearly defined. Research on student performance, teacher quality, postsecondary problems, and the influence of Appalachian culture on education in general reveals some patterns but completely fails to address the specific cultural effects of Appalachia on the teaching and learning of mathematics. Funded in 2001 by the National Science Foundation, the Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics (ACCLAIM) aims to cultivate indigenous leadership capacity for the improvement of school mathematics in rural places. ACCLAIM's strategies include implementing a research agenda that examines the effects of Appalachian culture on mathematics teaching and learning, promoting teaching methods that connect mathematics to students' culture and interests, and establishing cadres of leaders in mathematics education to support teachers. (Contains 70 references) (SV)

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Bridging the Gap between Culture and Mathematics: The Appalachian Perspective

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ACCLAIM's mission is the cultivation of *indigenous leadership capacity* for the improvement of school mathematics in rural places.

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Bridging the Gap between Culture and Mathematics: The Appalachian Perspective

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Bridging the Gap between Culture and Mathematics: The Appalachian Perspective

Central Appalachia, defined as the mountainous regions of eastern Kentucky, east Tennessee, southeastern Ohio and all of West Virginia, has a culture – one not only unique to other parts of the country, but unique to other rural areas. The people of Appalachia hold to a strong sense of family and community. Large extended families populate the region, and out-migration was low until recently. Schools vary greatly according to the resources available in the community. Schooling disconnected to communities is not highly valued; learning to work in the community is valued. The region also has the highest poverty and adult illiteracy rates; some of the lowest economic indicators; and one of the least dense populations in the country. Over the past century, the people and land of Central Appalachia have been stripped of many valuable resources. As a native of Central Appalachia and an educator interested building mathematics capacity in the area, I am keenly interested in the effects of Appalachian culture on mathematics teaching, learning, and attainment in the area.

For communities and regions to survive economically today, mathematics competency must be developed at high levels. According to *Before It's Too Late* (National Commission on Mathematics and Science Teaching for the 21st Century (NCMST, 2000), competency in mathematics is necessary to build an economic base because of "the rapid pace of change in both the increasingly interdependent global economy and in the American workforce" (p. 7).
The economies of Central Appalachia lag significantly behind those of other Appalachian and metropolitan areas. For example, in 1990, the poverty rate of Central Appalachia was 27 percent below the national average. In 1998, the region's labor force participation rate was 61.6 percent, compared to 67.7 percent nationally, and 27 percent of Appalachian counties were economically

distressed (exceeding by 50 percent national unemployment rates and per capita income) compared to 13 percent nationally (Appalachian Regional Commission, 2002, http://www.arc.gov.). The median family income in 1990 in rural areas was approximately 75% of the income in metropolitan areas. There are fewer skilled managerial positions and proportionally more laborer and low-skilled jobs in rural areas (Herzog & Pittman, 1995; McGranahan, 1994).

Jacobs (1984) argues that rural regions cannot keep pace with urban areas economically; cities are the engines of economic growth. People of rural areas must think deeply about the nature of economic growth and the need for it. They must weigh constantly the importance of individuality and community versus the need for economic success and growth. It is possible to have both, but the challenges are great. These dilemmas have implications for the nature of schooling in rural areas and for the role of mathematics in particular. As mentioned earlier, mathematics is key to economic health. Are there, however, other equally important roles mathematics can take? This paper, through an analysis of literature in the fields of mathematics education and rural education, will address this question and offer suggestions regarding the role of mathematics in Central Appalachia.

Effects of Culture on Mathematics Learning and Teaching

Much has been written about the relationships among culture, mathematics learning, and mathematics teaching. The writings span a range of topics that include the cultural bases for mathematics, mathematics development in different cultures, the historical culture of mathematics, the effects of culture on mathematics learning and on dispositions toward mathematics, and the political effects of mathematics on societies. Over the past twenty years, researchers in mathematics education have sought to understand how cultural differences affect students' performance in mathematics and their dispositions toward mathematics. The methodology for these studies has largely been comparative: researchers attempted to identify cultural factors that might explain differences in mathematics achievement and attitudes. These studies generally sought cultural differences among students from different countries (usually Asian and United States), among students from different racial or ethnic groups (Asian American, African Americans, Native Americans, Hispanic American, and Caucasian Americans), and among males and females. Analyses of these studies reveal five general cultural factors that seem to affect mathematics performance and dispositions. These factors include (a) societal influences; (b) parent attitudes, values, and beliefs; (c) teacher attitudes, values, and beliefs; (d) student perceptions and beliefs; and (e) language.

Societal influences

Leder (1992) suggested that societal influences on beliefs about gender differences in mathematics can be assessed through an analysis of media. She commented, "The important role played by the media in shaping ideas and attitudes, as well as reflecting and reinforcing popular beliefs, is widely recognized" (p. 612). She reported that Jacobs and Eccles (1985) found parents' beliefs about gender differences in mathematics could be shaped by the media. In an analysis of media reports, she noted that the media promoted a stereotypical view of gender competence and attainment levels in mathematics (Leder and Clarkson, 1984; Leder, 1986). Malloy (1997) suggested that the media's emphasis on achievement gaps had fostered stereotyping among African American parents, teachers, and students.

Parent Attitudes, Values, and Beliefs

Across all types of comparative studies – international, race/ethnic, gender – parent expectations have strong effects on student performance and attitudes. Leder (1992) reported

Armstrong and Price (1982) and Lantz and Smith (1981) found that students' attitudes and aspirations toward mathematics were linked to their parents' educational beliefs and expectations regarding school mathematics. In comparing Chinese and American parents, Stevenson (1987) noted that Asian parents believed that any child was capable of learning, but that American parents placed more emphasis on innate ability. He also found that American parents believed reading was more important than mathematics, while Asian parents believed that mathematics and reading were equally important. A large number of studies indicated that Asian parents emphasized effort as the key to success in school (Holloway, 1988; Mizokawa & Ryckman, 1990; Hess, Chih-Mei, and McDevitt (1987); Lee, Ichikawa and Stevenson, 1987).

Studies comparing Asian American students with Caucasian American students identified similar parental effects, although enculturation in the United States seemed to have lessened the cultural effects slightly. Chen and Stevenson (1995) found that parents of Asian American students held higher standards of achievement, believed effort was critical to success, and had more positive attitudes about achievement and studying diligently than their Caucasian American counterparts. Sue and Okazaki (1990) added that Asian American parents were more likely to insist on unquestioned obedience. Kao (1995) found that Asian American parents invested more in educational resources than their American counterparts. Hutsinger and Jose (1995) explored relationships among Chinese American and Caucasian American mothers, fathers, and daughter while they solved spatial tasks. They found that Chinese Americans were more respectful, more serious, and more orderly and that Caucasian Americans were more sociable, more talkative, and used more humor in solving the tasks. Furthermore, Chinese American parents talked less to each other and more to their daughters, whereas Caucasian American parents talked more to each other.

In comparing parents of African American, Caucasian American, Hispanic American, and Asian American students, researchers found that mothers all have equally high expectations for their children (Alexander and Entwisle, 1988; Stevenson, Chen, and Uttal, 1990; Galper, Wigfield, and Seefeldt, 1997). African American parents, however, reflect ambivalent and often contradictory values about education and their children (Ogle, 1991[in Kao]). Hispanic American parents were less confident that their children would get a good education or job after formal schooling (Galper, Wigfield, and Seefeldt, 1997).

As Nelson-Barber and Estrin (1995) noted, the parenting practices of Native American students tended to contradict traditional schooling practices. Traditional tribal learning emphasized "watch-then do" or "listen-then do" rather than "trial and error," which was often emphasized in schools (Moore, 1994, Swisher and Deyhle, 1989). Brod (1976) also noted that highly mobile Native American families had limited access to schools, and this mobility was a factor in their children's poor mathematics performance.

Teacher Practices, Attitudes, Beliefs, and Values

According to Zhonghong and Eggleton (1995), the Chinese mathematics curriculum reflects higher expectations for middle-school-age students than the U. S. mathematics curriculum. Stigler and Hiebert (1999) also found differences in teaching routines among Japanese, German, and American teachers. They noted that Japanese teachers challenged students more, introduced more advanced content, and spent more time analyzing and preparing lessons than their German and American counterparts. Valverde (1984) noted that school curricula did not reflect the intrinsic, cultural learning of Hispanic American students and that teachers were not prepared to address the cultural differences of Hispanic Americans. Bradley (1984) observed that many Native American students had extensive knowledge of mathematics deeply rooted in their culture and traditions; few teachers, however, tapped into this reservoir of traditional knowledge (Kawagley, 1990; Pomeroy, 1988).

Leder (1992), in an analysis of research on teacher interactions with male and female students in mathematics classrooms, observed subtle differences in the interactions. She noted that, in general, males received more criticism and praise, were monitored more frequently, and had more contacts with teachers. She also cited studies that found teachers generally supporting the notion that mathematics is a male domain (Fennema, 1990; Leder, 1986). In general, she concluded that the accumulative affects of these interactions and beliefs could have substantial impact on the ways females view their potential in mathematics.

Student Beliefs and Attitudes

Student beliefs and attitudes are often the products of their cultural heritage and, to a large extent, extensions of parental beliefs and attitudes. It is not surprising then that research reveals similar differences across different groups of students. Malloy (1997) suggested that school knowledge and cultural knowledge of African Americans sometimes oppose each other. Therefore, African Americans did not value school knowledge. Through interviews of African American high school students, Walker and McCoy (1997) found that students' perceptions of mathematics were related to familiar surroundings in home, school, and community, and that their motivation to learn mathematics was affected by a variety of factors such as teacher support, relevance, and extracurricular activities.

Despite poorer performance on most measures of mathematics achievement, American children were more optimistic about their performance and future in mathematics (Stevenson, 1987) and Hispanic students had high aspirations for rewarding careers (Anderson and Johnson, 1971; Espinoza, Fernandez, and Dornbusch, 1977; Juarez and Kuvlesky, 1968) than their Asian student counterparts. Ramirez and Castaneda (1974) found that Hispanic American students tended to be more field dependent than Caucasian American students. According to Malloy (1997), "African American students generally learn in ways characterized by social and affective emphases, harmony with the community, holistic perspectives, field dependence, expressive creativity, and non-verbal communication" (Stiff, 1990; Willis, 1992).

Language

Language also can serve as a barrier to learning mathematics. For example, Geary and others (1997) found that the language structure of Asian number names assisted Chinese children in developing meaningful early number concepts. Valverde (1984) noted that differences in English and Spanish contribute to Hispanic Americans' poor performance and involvement in mathematics. Moore found that the Native American language did not align well with traditional mathematics vocabulary and terms and causes learning problems for Native American students.

Education Indicators in Appalachia

None of the studies in the previous section were conducted in rural contexts, largely because rural "culture" is not clearly defined. Rural contexts are different not only across the United States, but also within Central Appalachia. For example, within the same geographic area of Central Appalachia are families living in the fairly populated cities and families living in highly isolated areas. The experiences, beliefs, and economics of these families can be dramatically different even though they live within 30 miles of each other. Small city schools can be different than small mountainous community schools or large consolidated county schools.

There are virtually no studies exploring the varying rural effects on mathematics teaching and learning because few mathematics education researchers have chosen to study this area (Schultz, 2002). While much can be learned from the previously cited studies on culture and mathematics, little information exists about the effects of culture in specific rural areas. For now, educators in these rural areas must turn to literature on the general effects of rural contexts on education and apply them to mathematics.

Indicators of Educational Success

Indicators of educational success in rural areas, and particularly the region of Central Appalachia, are rarely positive. General indicators almost always fall below national averages.

Student Performance. On the national level, students from low socioeconomic backgrounds perform at mathematics achievement levels lower than students from higher socioeconomic backgrounds (Abt Associates, 1993; Mullis et. al., 1994). Patterns of mathematics achievement in the rural areas of Appalachia support these national findings. In particular, eighth-grade students from three partner states in Central Appalachia participated in the 1996 NAEP Mathematics Assessment (Reese et al, 1997). Eighth-grade students in all three states scored below the national average. Furthermore, students in Appalachian areas of these states scored at lower levels than other students in other regions of the states.

Formal education attainment tends to be lower in rural areas. In 1990, high school completion rates were almost 8% lower than those in metropolitan areas, and about 9% fewer rural students completed college (Herzog & Pittman, 1995). Furthermore, rural students were less likely to take college preparatory classes in high school (Stern, 1994), and rural students who did attend college tended to leave the area (Ballou & Posgursky, 1998; Herzog & Pittman, 1994; McGranahan, 1994; Seal & Harmon, 1995). Since few institutions of higher learning are located in rural areas, residents are reluctant to pursue higher degrees (DeYoung, 1995; Howley & Howley, 1995; Seal & Harmon, 1995).

These broad indicators, however, do not accurately depict education in Central Appalachia. Across the region can be found high performing students who eventually attend some of the most prestigious postsecondary institutions in the country. Some of the schools in the area exceed by far state averages on state accountability assessments for student performance in mathematics. It is this dichotomy of a general undereducated area with pockets of educational excellence that makes describing education in the area so complex.

Teacher Quality. The American Association of School Administrators (1999) reports that the main problem of rural school districts is attracting and keeping quality teachers. The problem is especially acute in high-need areas like mathematics, science, and special education. According to respective state department sources, 28.3 percent of mathematics teachers in Kentucky teach out of field. In Tennessee, 27 percent of mathematics teachers teach out of field. These reports confirm that finding and retaining qualified mathematics teachers is one of their greatest problems. Research on teacher recruitment and retention indicate that rural teachers leave teaching because of geographic isolation, weather, distance from larger communities, and an assortment of family-related reasons (Murphy and Angelski, 1996/1997).

On the national level, knowledge and teaching expertise of rural teachers is also a problem (NCMST, 2000). In rural areas, the problem is exacerbated. One-third of the teachers in high-poverty schools teach without having at least a minor in the subjects they teach (Darling-Hammond, 1997). Coining the phrase "the pedagogy of poverty," Haberman (1991) found that, in schools of high economic need, poverty defines what teachers do, what students come to expect, and what both parents and the public presume. Teachers tended to be much more traditional, students expected less of themselves and others, and parents and the public presumed learning cannot occur. As a result, student achievement often was considerably lower.

Like the complexity of student performance and attainment in Appalachia, teacher competence also reflects a complex dichotomy. Despite these general indicators, the region has some of the best and most caring teachers in the country. They are deeply committed to their students, their schools, and their communities. Unfortunately, many of these teachers work in professional isolation. Some teachers have found important ways to connect the mathematics they teach to students' lives.

Recent population data indicate that families are moving out of the sparely populated areas of Central Appalachia into the more densely populated cities in the area. This out-migration has caused an abundance of teachers in the remote areas and shortages of teachers in larger communities. Teachers in some areas are actually losing their jobs.

Postsecondary Institutions. Central Appalachia has approximately 65 postsecondary institutions that prepare teachers of mathematics. Many of these postsecondary institutions face the same challenges as rural schools—limited or inadequate resources, difficulty in attracting qualified faculty and staff, and difficulty in attracting students. With an extreme national shortage of doctoral candidates in mathematics education (Reys, 2001), rural teacher education programs struggle to find faculty with the necessary expertise in mathematics and mathematics education. Many faculty who prepare mathematics teachers in rural areas often are not adequately prepared to work with teachers (Horn, 1983; Muse, 1977). They are often "outsiders" who do not necessarily understand the needs of individuals and communities in the area. Furthermore, many faculty in mathematics departments often do not understand the content needs of K-12 mathematics teachers, nor are they familiar with K-12 mathematics curricula. Faculty in education departments are often generalists who do not have specific knowledge of mathematics education concepts and resources.

The Influence of Appalachian Culture on Teaching and Learning

A body of research reveals, for example, that poverty and isolation in rural areas affect the education infrastructure. Through a careful review of research on rural education, Kannapel and DeYoung (1999) and Kannapel (2000) noted a significant conflict within rural schools, particularly in Appalachia, with regard to curriculum, instruction, and assessment. On the one hand, national and state educational reform offers standards for all students and schools. These standards rightfully represent what is necessary to build a strong national infrastructure in mathematics. Because high-stakes accountability of districts, schools, and teachers is often attached to these standards, rural teachers must address them. On the other hand, local communities, which have powerful influences on schools, place higher priority on individual growth and community contributions. They are less concerned with national priorities and issues. Rural teachers are caught in the middle of these conflicting priorities. They must find a balance between recognizing the needs of the community and helping their community understand its needs with regard to mathematics as represented in national standards. They must also help their community realize that a deeper knowledge of mathematics can benefit the community and that mathematical knowledge need not be reserved only for those who wish to leave the community.

The social norms of rural areas value place, community, and family over other priorities. Rural families tend to adopt more traditional values such as hard work, discipline, and relationships (Haas & Nachtigal, 1998; Nachtigal, 1982; Seal & Harmon, 1995). Rural residents tend to select low-paying jobs close to family and friends over high-paying jobs some distance away (Seal & Harmon, 1995; DeYoung, 1995). According to Nachtigal (1982), rural communities tend to be homogeneous in race and socioeconomic status (e.g., the Appalachia is largely Caucasian; the Mississippi Delta is largely African-American).

Rural schools tend to be the center of the community (DeYoung & Lawrence, 1995; Herzog & Pittman, 1995, Nachtigal, 1982; Stern, 1994). They tend to be smaller than urban schools, despite 20 years of consolidation efforts (Sher, 1983; Stern, 1994). Community support for schooling is less, however. Rural adolescents often are conflicted about career aspirations because the pursuit of higher education takes them out of the community (Task Force on Teaching and Learning in Poor Communities, 1999).

Understanding the Effects of Culture

Drawing conclusions about the effects of culture on mathematics teaching and learning in Central Appalachia based on these studies of general education poses a challenge. The general cultural effects on mathematics teaching and learning have been clearly established, and some research on the effects the Central Appalachian culture on education in general reveals some patterns. This research, however, completely fails to address the specific cultural effects of Appalachia on the teaching and learning of mathematics. Hypotheses about these effects, however, emerge from the two larger bodies of research. In formulating these hypotheses, several caveats arise. First, as mentioned earlier, not all rural is alike. The rural of Central Appalachia is different from the rural of Kansas, the rural of Mississippi, the rural of the southwest, or the rural of Alaska. The cultures are simply not the same. Furthermore, within Central Appalachia are diverse beliefs and expectations about education. One must be careful in generalizing too broadly from the research on rural effects, including research in Central Appalachia. Second, learning and teaching mathematics is different than learning and teaching literacy, science, or social studies. Community members, parents, and teachers hold views about the value of mathematics learning different from their views about becoming literate. While some may value education in general, they may not value a mathematics that seems disjoint from their community and needs. They may not see the connection between mathematics and economic growth or even care about it. This caveat represents a more fundamental dilemma – the varying roles of mathematics in schooling. In cosmopolitan areas, mathematics is necessary for college, which is necessary for economic success. These schools offer mathematics curricula that prepare students for a competitive economic world. These curricula are not always appropriate in rural schools, where parents and community members need mathematics to do their work. Often the mathematics in which students engage is not useful for them and not connected to their future work. The dire outcome of this scenario is that students who are typically talented in school mathematics usually leave the area to pursue careers that require their mathematics ability.

Strategy for Bridging the Gap in Central Appalachia

The Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics (ACCLAIM) was funded in 2001 by the National Science Foundation as one of 10 Centers for Learning and Teaching nationally. The partners of ACCLAIM include Ohio University, the Kentucky Science and Technology Corporation, Marshall University, the University of Kentucky, the University of Louisville, and the University of Tennessee. The primary mission of ACCLAIM is the cultivation of *indigenous leadership capacity* for the improvement of school mathematics in rural places. Understanding the cultural effects on mathematics teaching and learning and establishing a bridge between culture and mathematics in

Central Appalachia are critical steps in carrying out this mission. ACCLAIM has designed a plan, based on the literature available, to enhance mathematics capacity in the area.

First and foremost in the plan is to create and implement a research program that describes the effects of culture in Central Appalachia on mathematics teaching and learning. In particular the research program will investigate community, parent, teacher, and student beliefs about mathematics, as well as about mathematics teaching and learning. Some of the many research questions that will emerge include:

- What are community perceptions of, beliefs about, and attitudes toward mathematics in Appalachia?
- Where do Appalachian students capable in mathematics go?
- What roles do mathematics teachers play in Appalachian schools and communities?
- Should mathematics curriculum developed at the national level be adapted for students in Appalachia?
- Should professional development for Appalachia teachers differ from professional development designed for all teachers? If so, how?

Until educators understand the complexities of the cultural effects on mathematics teaching and learning in the area, strategies for helping teachers, administrators, and policy makers improve mathematics education run the risk of being off target.

Second, ACCLAIM will target changing practices and policies on a variety of levels – from classrooms to schools to postsecondary institutions to regional and state policy makers. While ACCLAIM targets many levels, the primary focus for change will be the learning and teaching of mathematics in classrooms. The research on the cultural effects on mathematics and on education in rural areas like Appalachia reveal one point of intersection – the importance of attaching learning to individuals and communities. Mathematics educators believe that the mathematics taught in schools should be connected to students' culture and interests. According to the *Principals and Standards for School Mathematics* by the National Council of Teachers of Mathematics (2000), "School mathematics experiences at all levels should include opportunities to learn about mathematics by working on problems arising in contexts outside of mathematics. These connections can be to other subject areas and disciplines as well as to students' daily lives" (pp. 65-66). Rural educators, and specifically the Rural and Community Trust, tout the success of "place-based" curricula that attaches school subjects to local communities (Haas and Nachtigal, 1998; Haleman and DeYoung, 2000; Haskins, 1999; Smith, 2002; Theobald and Curtiss, 2000). ACCLAIM will bring together the NCTM focus on connections to daily lives with the place-based concepts of rural education in order to elevate the relevance and use of mathematics in Central Appalachia.

At the classroom level, ACCLAIM will assist teachers in altering nationally developed curricula or developing curricula that connects mathematics to students' lives. New NSF-funded, standards-based mathematics curricula have students solve problems, investigate ideas, and make connections to daily life. Unfortunately, few of these curricula have applications that connect directly to Appalachian communities (Schultz, 2001). ACCLAIM will assist Appalachian teachers in making these connections.

ACCLAIM also will establish cadres of leaders in mathematics education to support teachers. The leaders will provide job-embedded professional development, teach courses in local postsecondary institutions, and provide web-based distance learning support. Finally, ACCLAIM will provide policy makers and decision makers the necessary information and data about best practices so that teachers and leaders will have appropriate resources and technology to be effective. Through this three-pronged approach, ACCLAIM hopes to produce mathematically capable students, teachers well grounded in mathematics, and administrators and policy makers who see the value of learning mathematics in rural communities. Figure 1 below illustrates the levels that ACCLAIM will target. Through a comprehensive, systemic effort, ACCLAIM hopes to enhance and develop mathematics capacity in the area. This effort will lead to an appreciation of mathematics as a building block to economic growth, as well as an important knowledge base for rural communities. This reform, as with any comprehensive reform, will take years of collaborative and focused effort.

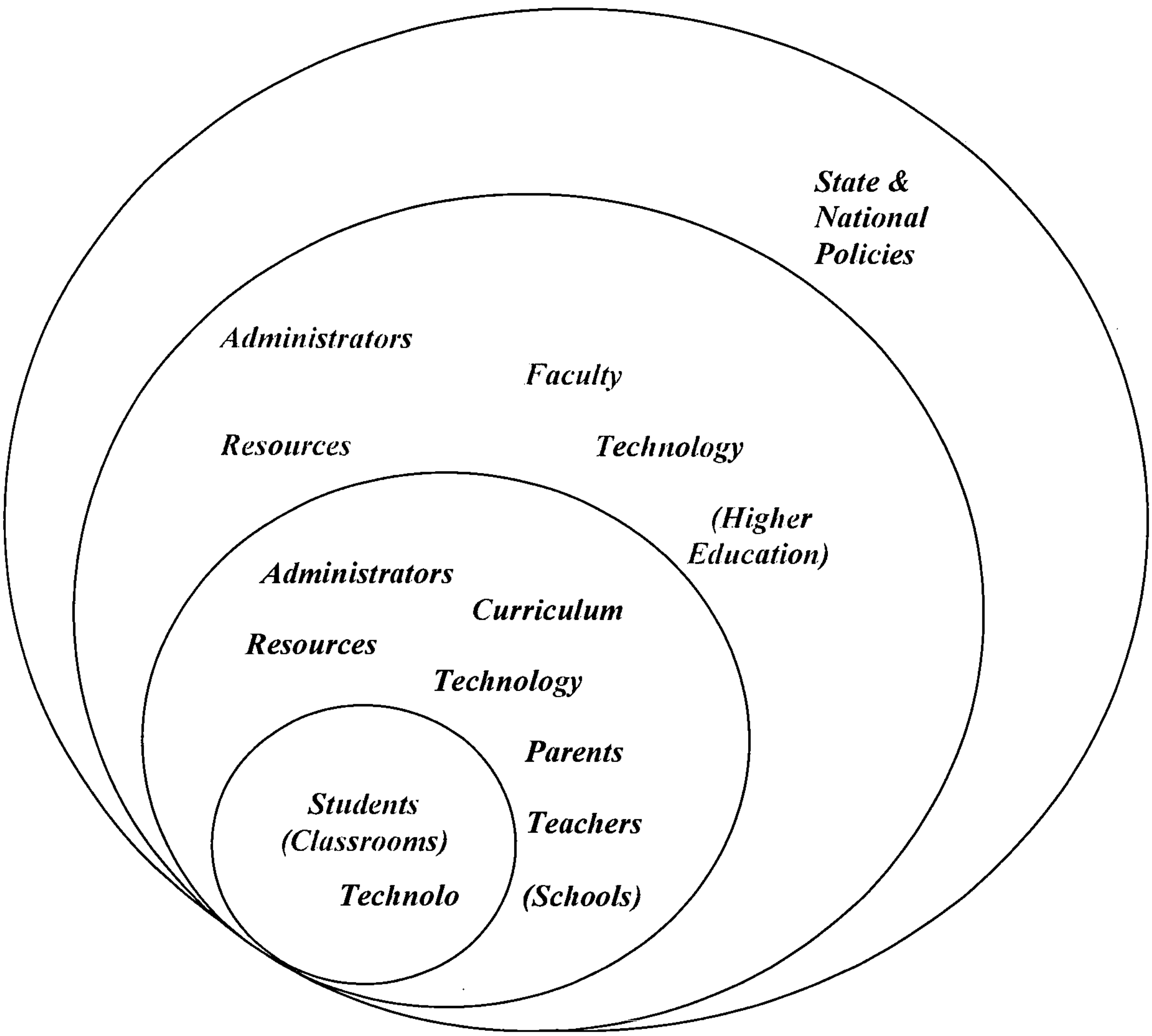

Figure 1: Levels Targeted by ACCLAIM

All children have a right to be capable in mathematics. Often cultural beliefs and practices establish barriers to learning, especially in mathematics. Central Appalachia, with a long history of economic and educational problems, is fertile ground on which to build mathematics capacity. By understanding the complex culture of Central Appalachia, with its keen focus on communities and individuals, mathematics educators can learn to build on the existing strengths and capacities of the region, to produce citizens who are mathematically capable to pursue any career or occupation in the region.

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