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Does Size Make a Difference? Variations in the Preparation and Literacy of High School Earth Sciences Teachers

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This study expands geographical education into the area of teacher preparation and literacy in high school earth science instruction. Considerable research has focused on the impact of school size on instruction and learning; however, little work has been done in comparing school size with the degree to which high school science teachers are prepared to teach specific subjects like earth science. Indices of teacher preparation and literacy were examined across school size categories and geographic regions in North Carolina. Preliminary findings in this research indicate that a relatively large percentage of earth science teachers in small schools have never taken a course in this subject area. Survey results also show that teachers from smaller schools are not as knowledgeable about basic concepts in earth science as teachers from larger schools. It was found that the teachers surveyed were especially deficient in their knowledge of geographic concepts.

The importance of public education in general is a national concern as evidenced by the "no child left behind" policy of President George W. Bush's Administration. An important component of geographic education is the study of earth science. This paper attempts to address the issue of school size in relation to teacher preparation and literacy in earth science instruction. Recent studies on enhancing quality teaching in the classroom have focused on such pedagogical strategies as group learning, critical thinking, and the use of technology (Bain, 1998; Andrews, 2000; Robertson, 2000). While these approaches to better instruction are important to consider, a more fundamental issue is the preparation and literacy of teachers in subject areas like earth science. This paper addresses teacher preparation from the standpoint of the degree to which teachers in North Carolina high schools have prepared themselves to accomplish effective earth science instruction, by considering the number of courses they have completed in this subject area at the undergraduate and/or graduate level. Teacher literacy in earth science is measured by their knowledge of important concepts in the field. Both teacher preparation and literacy are viewed in terms of their

variation across school size categories and among geographic regions.

Much research has been done on the problems and challenges that public school teachers face, and their ability to provide effective instruction. These challenges are especially acute in impersonal environments that many large schools can create, because of the difficulty of working within burgeoning bureaucracies of large school district administrations. These difficulties are further exacerbated when science teachers are given the responsibility of teaching earth science when they have had little or no formal training in the subject. Historically, earth science has not been given the same emphasis as other sciences such as chemistry, physics and biology in high schools and in undergraduate curricula. In fact, only recently (academic year 1999-2000) has earth science become a required course in North Carolina high schools. The lack of adequate course work preparation by science teachers to teach earth science has limited their effectiveness to teach this subject.

Despite considerable research on the effect of school size on instruction and on learning, little work has been done in comparing school size with the degree to which high school science teachers are

prepared to teach specific subjects like earth science. In contrast to instructional issues, most research on this topic has addressed the difficulties in the administration of schools with extremely large student enrollments (Oxley, 1994; Portner, 1996; Howley, 1997). Larger school size is generally associated with greater challenges because of increased student diversity in ethnicity, social class, and ideologies. Larger school size has also been associated with high dropout rates (Alspaugh, 1998). Large school districts have been associated with population growth and migration patterns in the last half of the twentieth century. As people migrate to larger populated areas, new kinds of school organizations emerge that lead to "depersonalization" in larger schools (Lewis, 1999).

While it may be argued that larger schools attract more qualified teachers, the quality of instruction may be compromised because of more class time spent dealing with discipline issues rather than focusing on instruction. While discipline concerns are not exclusive to large schools, they may be disadvantaged because of more diverse student populations and impersonal environments. Many teachers are not properly trained to deal effectively with issues of interpersonal relationships and social interaction (Blair, 2000).

On the positive side, some studies document that larger schools, characteristic of larger school districts, may be more effective in student learning despite higher dropout rates. Weast (1997), for example, studied the merger of three school districts in Guilford County, North Carolina, and found that student reading, writing and math skills had improved over a three year period while the dropout rate fell to the lowest level among large districts in the state. Also, despite the challenges that larger schools face, there is some evidence that they experience higher academic achievement than small schools regarding SAT scores and on the percentage of students who take the test (Gardner et al., 2000).

In contrast to larger schools, smaller schools are said to offer more effective learning due to more positive interpersonal relationships and fewer discipline problems (Raywid, 1998; Ark and Wagner, 2000; Blair, 2000). Parents apparently agree that

smaller schools are generally better for their children's education, but indicate that the very best teachers are probably not attracted to these smaller schools (Bainbridge and Sundre, 1990). Nonetheless, small schools are likely to be more manageable, and may provide a more conducive environment for instruction. One study suggests that smaller schools have better student attendance and create a greater sense of community among teachers and students (American Teacher, 1995).

The regional variation in teacher preparation and literacy may reflect fewer resources going to smaller school districts and lower teacher salaries. Lower teacher pay, as a consequence of fewer resources in smaller school districts, tends to discourage more qualified teachers in seeking employment within rural school systems. A greater sense of belonging and caring for the welfare of students, apparently characteristic of smaller schools, has been linked to minority and less advantaged students receiving more effective instruction in these environments (Stiefel, et al., 2000). These inherent qualities in smaller schools have been linked to fewer layers of bureaucracy (Black, 1996; Lee, et al., 2000). Other studies contend that regardless of their size, schools should be more attuned to the concerns of the surrounding community. For example, the concern of parents regarding student learning has been linked to the preparation that teachers receive in providing effective instruction to their children (Gursky, 2001).

One model that suggests decreasing school size lead to more efficiency in instruction comes from British private schools. The model considers schools as "houses" and suggests that smaller houses lead to such desirable results as more effective management of extracurricular and co-curricular activities, student group activities, physical resources, administrative support, and teacher involvement (Oxley, 1994). Thus, the result of smaller school size is believed to enhance the learning potential of students (Cushman, 2000). One school administrator contends that the greatest advantage of small schools is that there are fewer layers of bureaucracy to interfere with rescuing at-risk children (Black, 1996). A review of these issues is

necessary in order for improvements to be made in classroom instruction. In North Carolina, this is especially significant given the introduction of earth science as a requirement for graduation from high school.

Methods

North Carolina was selected for this study because of a concern among public school administrators for quality teaching in earth science, which was made a requirement for high school graduation starting in the 1999-2000 academic year. This policy change in the state's public schools reflects the growing importance of earth science in school curricula. In this study, high school earth science teacher preparation and literacy are examined across school size categories and geographic regions.

The research was developed in two stages. The first stage involved the acquisition of teacher preparation and literacy data, establishment of school size categories, and division of the state into geographic regions. A package with two questionnaires was mailed to the science chairs of 310 high schools representing 117 school districts in North Carolina. One questionnaire was included for the science chair to complete, requesting information about student enrollment (to indicate school size), the number of science teachers at the school, and the number of years earth science has been offered. The second questionnaire was for all science teachers (including the science chair). This questionnaire included items concerning the preparation and literacy of science teachers as it related to their earth science teaching experience during the 1999-2000 academic year. Only questionnaires returned by science teachers who had taught earth science during this period were used in this study. A total of 75 questionnaires were returned representing 24.2 percent of the high schools originally contacted. Science teachers who taught earth science during the 1999-2000 academic year returned a total of 63 questionnaires. The data were divided into school size categories and geographic regions.

School size categories were divided into small (up to 1000 students); medium (1001 to 2000 students); and large (more than 2000 students). In order to make regional comparisons the state was divided into geographic regions based on the telephone area code map of North Carolina, and are as follows: Northeast (NE), Southeast (SE), East North Central (ENC), West North Central (WNC), Southwest (SW), and West (W).

Both the NE and SE regions are primarily rural and physiographically are part of the state's coastal plain. The W region is also rural but is largely a mountainous area. These three regions contain some of the state's smallest school districts. The three other regions (ENC, WNC and SW) lie in the piedmont and contain both the state's largest urban areas and some of the largest school districts. The SW region includes the state's largest city (Charlotte) in Mecklenburg County and also represents the state's largest public school system. The ENC region contains the second largest school system in Wake County, which has the state capital of Raleigh, which is the second largest city in the state. This region also has the Durham County and City School systems, which together form one of the larger systems in the state. The WNC region has the third and fourth largest school systems in the state in Guilford County (Greensboro) and Forsyth County (Winston-Salem).

The second stage of this research dealt with developing a set of indices for teacher preparation and literacy. To develop indices of teacher preparation, the question was asked: how many undergraduate and/or graduate courses have you taken in earth science or a related area? Tabular, graphic, and map presentations are used to show the percentage of teachers having taken earth science or a related course for school size classes and within designated regions.

To address literacy, a scale was developed to ascertain the teacher's degree of knowledge of some major concepts in earth science. Teacher literacy was addressed using the following scale of familiarity:

- *I have never heard of the concept.*
- *I have heard of the concept but do not know its definition or meaning.*
- *I am slightly familiar with the concept.*
- *I am familiar with the concept.*
- *I am very knowledgeable of the concept.*

This scale was used in the teachers' responses to their familiarity of the following earth science concepts under associated subject areas: 1) Atmospheric Science (Coriolis Effect, Greenhouse Effect, and Hydrologic Cycle); 2) Geology (Plate Tectonics, Groundwater, and Rock Cycle); 3) Geography (GIS and Spatial Analysis); and 4) Environmental Studies (Food Chain and Photosynthesis). GIS is an abbreviation for Geographic Information System, which is defined as a computer-based set of procedures for assembling, storing, manipulating, analyzing, and displaying geographically referenced information (Getis, et al., 2002). With the exception of GIS and spatial analysis in Geography, the selected subject areas are found in the basic categorization of most contemporary earth science textbooks (see Murphy and Nance, 1999). GIS and spatial analysis are considered because they form the foundation by which earth science concepts are examined spatially using current technology (Eastmond, 2000).

To determine literacy in earth science, teachers were asked to assign a number from 1 to 5, corresponding to their degree of familiarity described above, for each of the ten concepts. The number represents an assigned familiarity weight with respect to a given concept. As with any survey, the authors are assuming that the teachers are being truthful and accurate in their responses. To arrive at specific teacher literacy indices, two procedures were carried out. First, the weights each teacher recorded for the ten selected concepts were summed and divided by the total number of concepts, to arrive at an average

weight for each teacher within school size categories. Subsequently, a table was constructed to show the number of teachers within each familiarity category based on their average weights.

Second, for each teacher, their degree of familiarity for each concept within a given subject area was summed and divided by the number of concepts within that subject area. These individual averages were then summed and divided by the total number of teachers to arrive at an average familiarity for each subject area.

Findings

Teacher Preparation and School Size

Figure 1 shows the variation of teacher preparation as measured by the percentage of teachers surveyed having completed earth science or related courses at the undergraduate and/or graduate level. The most evident aspect of these data is the relatively large percentage of teachers from the small school size category that have never taken a course in earth science and who, consequently, lack the course experience to provide the most effective instruction in this subject. On the other hand, a relatively large percentage of teachers from the large school size category (four of five teachers or 80 percent) have completed five or more courses in this area. While these findings are far from conclusive based on the small number

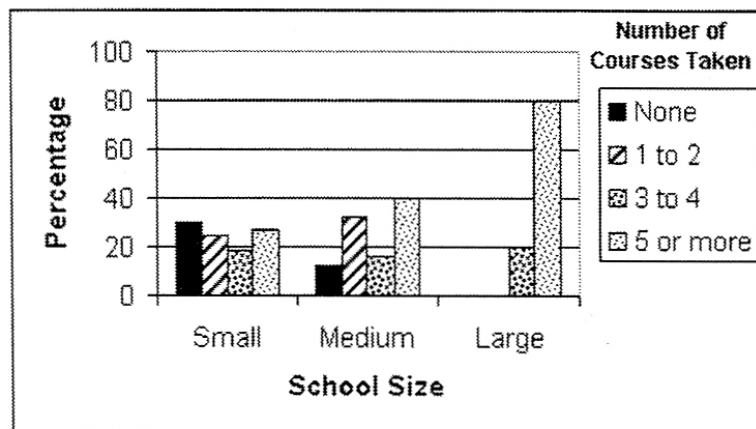


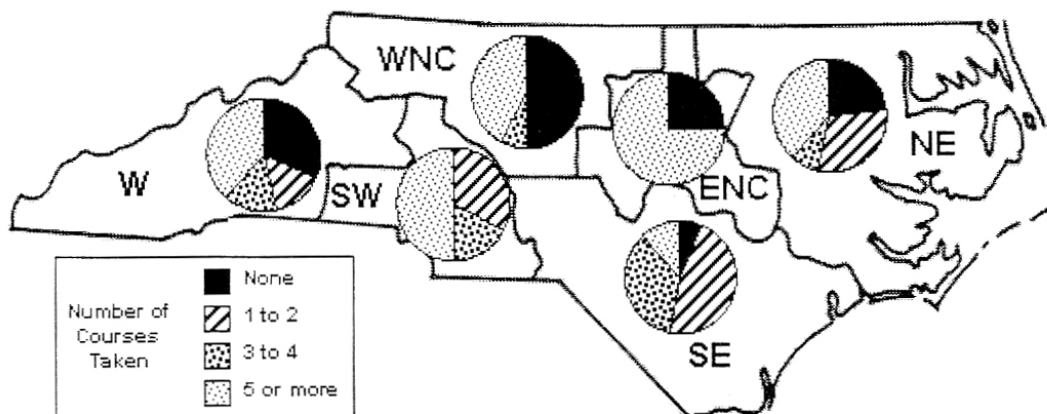
Figure 1. Variation of teacher preparation in each school size category as measured by the percentage of teachers having completed undergraduate and/or graduate courses in earth science or related areas.

of teachers responding in this category, it suggests support for the view that the more qualified teachers with better preparation in earth science are attracted to large school systems. That is, better-prepared teachers are hired by larger and wealthier school districts; so less qualified instructors end up in the smaller districts that are likely to have fewer financial resources to offer competitive compensation. This is consistent with parents' concerns that their children are not taught by the best teachers in smaller schools (Bainbridge and Sundre, 1990).

A closer examination of teacher preparation among size categories reveals that of the five teachers in the large size class who responded to the survey, four have completed five or more courses and one has completed four courses in earth science (Table 1). The lowest percentage of teachers having completed five or more courses in earth science or a related area came from the small schools at about 27 percent. Teachers from the small schools overall have the highest percentage having never taken an earth science or a related course at 30 percent. The small schools also have the highest percentage of teachers who have completed only one earth science or related course at 15.2 percent. It should be pointed out that while the numbers of respondents for small and medium school size are relatively similar (33 and 25 responses, respectively), the small number

of responses from large schools (5) may cause comparisons to be somewhat skewed.

Map 1 shows the regional variation in teacher preparation. The SW and ENC regions have the highest percentages of teachers with five or more earth science or related courses at or over 50 percent. These regions contain the two largest school systems in the state (Mecklenburg County and Wake County respectively). The regional analysis suggests teachers with more experience (with respect to courses taken in earth science) are attracted to areas with larger sized schools. In fact, the SW region, with the state's largest school district, is the only area lacking a respondent who had not completed at least one earth science or related course. The WNC has the highest percentage of teachers that have not taken any earth science or related course at 50 percent. This result may reflect the high proportion of the population in this region living outside of Forsyth County, which contains Winston-Salem, its largest city. Smaller sized schools within this relatively large region, but outside of the Winston-Salem/Forsyth County School District, may follow the pattern that small school size is associated with teachers that have taken little or no course-work in earth science. A more definitive conclusion about this association will be provided with further research at the intra-regional level of analysis. The smaller populated W and the NE regions also have relatively high percentages of



Map 1. Map of regional variation in teacher preparation. Wedges of the pie charts are proportional to the percentage of teachers who have completed a defined number of undergraduate and/or graduate courses in earth science or related areas.

teachers that had not completed a course in earth science, but did not exceed 50 percent. The SE region has less than 25 percent in this teacher preparation category.

Teacher Literacy and School Size

Table 2 shows the number of teachers within familiarity categories for all subject areas in earth science combined (refer to scale of familiarity under Methods). Each school size category has at least one teacher who was “very knowledgeable” about all ten subject areas. The large school size class has the highest percentage of teachers “familiar” with the subject areas at 80 percent; the medium size schools has the next highest percentage of teachers in this category at 68 percent; the smallest size schools has the lowest percentage at 41 percent. The small size class has a higher percentage of teachers “slightly familiar” with the concepts than the medium size category (53 percent and 24 percent respectively). There were no respondents in the “never heard” category.

Table 3 shows the weight average for teachers’ responses to their knowledge of the individual selected subject areas in earth science by school size class. The most evident aspect of the table is that the larger size schools has higher averages for each subject area than either the medium or small size schools. The highest weight average for large size schools is for Geology at 4.9, followed by Atmospheric Science at 4.8 and Environmental Studies at 4.7. Geography has the lowest weight average in the large school size class at 3.5. This subject area also has the largest difference between large schools and small schools. While the weight average for Geography of 3.5 is the lowest average among the three other subject areas in the large size class, this subject’s weight average for the small size schools is considerably lower at only 2.3, a difference of 1.2 points. This reflects the largest difference in weight average among the selected subject areas. In contrast to Geography, teachers in large schools score only 0.7 points higher than those in small schools in Geology. For this subject area, large schools have an average of 4.9, medium schools 4.5 and small schools 4.2. For Atmospheric Science the

variation is 0.8 in which the weight average progression is 4.8 for large schools, 4.6 for medium schools, and 4.0 for small schools. The weight averages are the most similar among the school size classes for Environmental Studies. Similar to the other subject areas, larger schools have a slightly higher weight average (4.7) than the small and medium-size school categories (4.6). This suggests teachers in all size categories have the same relative knowledge of the selected concepts in Environmental Studies (the 0.1 variation between high and low weight average for the size categories is not considered important), and that they have a fairly high literacy level in this subject area.

Overall, these findings indicate that the selected topics in Geography are the least familiar to all the respondents. This has important implications with respect to the ability of North Carolina students to comprehend major concepts in this subject area, especially the growing use of GIS in applications such as city and regional planning. Students’ ability to address problem-solving issues utilizing critical thinking skills may be dramatically enhanced by knowledge of this popular tool in human geography.

Figure 2 shows the regional variation in teacher literacy as measured by the weight average for teacher responses to their knowledge of the selected subject areas in earth science by school size. A pattern that emerges is that for each region of the state there is a slight increase in the weight average with increasing school size categories. The ENC region is an exception because the respondents come from one size class. The large size schools that returned the survey come from the SW and SE regions. The weight average of teachers in the SW region is higher than for the SE region, but both regions follow the state-wide pattern of an upward progression in weight average for the selected concepts combined with increasing school size (Table 4). The weight average for the SW region is 4.7 for large schools and 3.9 for medium size schools, a difference of 0.8. The SE region has weight averages of 3.5, 4.0, and 4.2 for small, medium, and large size schools respectively. The difference in the weight average between small schools and large schools

for this region of 0.7 is slightly less than the 0.8 registered for the SW region. Other regions in the state in which small and medium size schools having submitted the survey also have increases in weight average with increasing school size class. The W region has the highest weight average among this group at 4.6 for medium size schools compared to 4.2 for small size schools. Both the NE and ENC regions have weight averages of 4.4 for the medium size class; the NE region weight average for small size schools is 4.0 while the ENC region did not have a teacher represented for this size class. The remaining region, the WNC, has a weight average of 4.2 for medium size schools and 3.9 for small size schools.

These findings indicate there is little regional variation in teacher literacy based on the selected measures. However, there is a consistent variation among size categories within regions across the state with regards to weight averages. Specifically, teachers from smaller schools have slightly lower weight averages than those from larger schools with regards to their familiarity of the concepts under the selected subject areas. It is not clear whether advantages of smaller schools such as having less bureaucracy (Black, 1996; Lee, et al., 2000) and a greater relationship with the community (Gardner et al., 2000) can overcome perceived or real limitations in teacher preparation and literacy. Also, highly qualified teachers appear to be attracted to larger

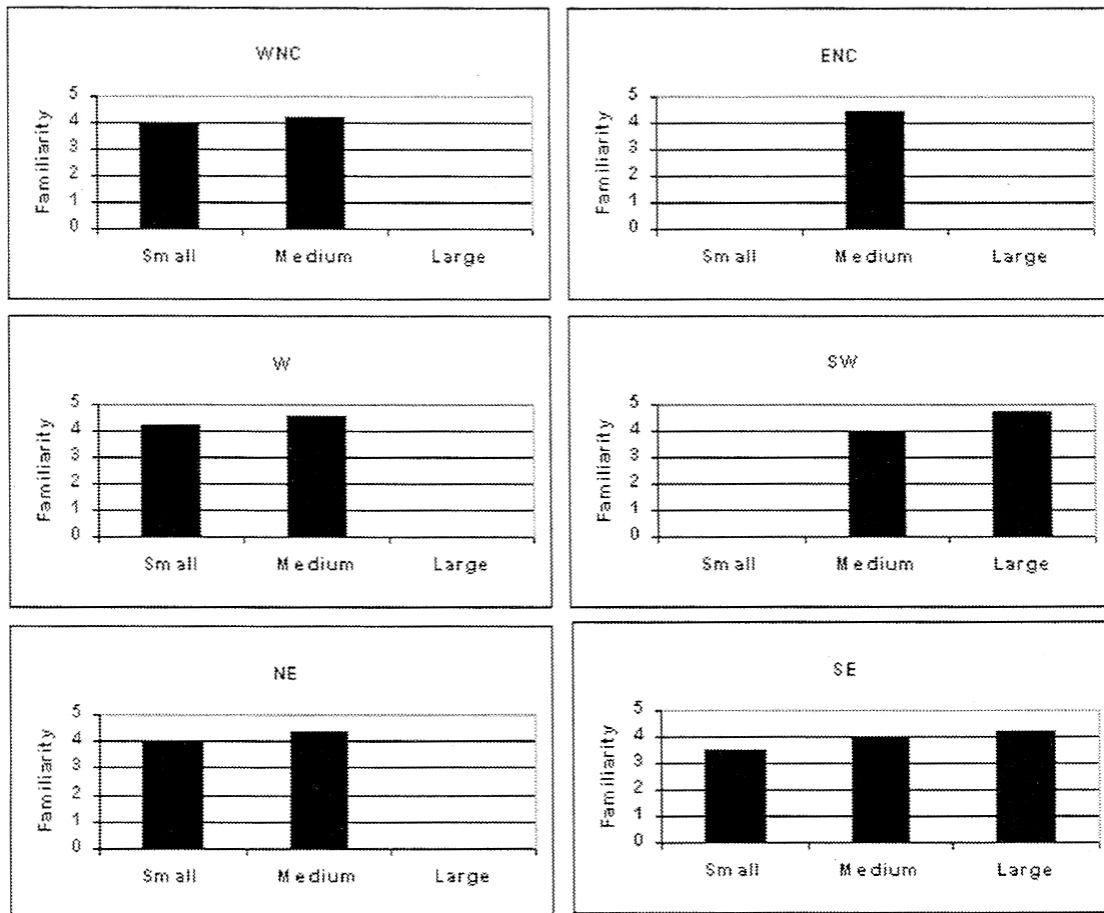


Figure 2. Regional variation in teacher literacy (familiarity) by school size category as measured by the weight average of all ten subject areas (see Table 4).

Table 1. The number of teachers having completed courses in earth science as a measure of teacher preparation by school size.

	None	1	2	3	4	5	Total
	No.	No.	No.	No.	No.	No.	No.
	%	%	%	%	%	%	%
Small N=33	10 30.3	5 15.2	3 9.1	5 15.2	1 3.0	9 27.3	33 100
Medium N=25	3 12.0	2 8.0	6 24.1	3 12.0	1 4.0	10 40.0	25 100
Large N=5	0 0.0	0 0.0	0 0.0	0 0.0	1 20.0	4 80.0	5 100

Table 2*. The number of teachers within weight average categories for all concepts in earth science as a measure of teacher literacy by school size category.

	1.00-1.99	2.00-2.99	3.00-3.99	4.00-4.99	5.00	Total
	No.	No.	No.	No.	No.	No.
	%	%	%	%	%	%
Small N=33	0 0.0	2 6.3	16 50.0	5 15.2	13 40.6	32 100
Medium N=25	0 0.0	1 4.0	6 24.0	3 12.0	17 68.0	25 100
Large N=5	0 0.0	0 0.0	0 0.0	0 0.0	4 80.0	5 100

Table 3*. The weight averages for teachers' response to their knowledge of individual selected topics in earth science as a measure of teacher literacy by school size category.

	Atmospheric Science	Geology	Geography	Environmental Studies
Small N=33	4.0	4.2	2.3	4.6
Medium N=25	4.6	4.5	2.8	4.6
Large N=5	4.8	4.9	3.5	4.7

Table 4. The weight average for teacher's response to their knowledge of the selected concepts combined by region and by school size category. --- indicates no response.

	NE	SE	ENC	WNC	SW	W
Small N=33	4.0	3.5	---	3.9	---	4.2
Medium N=25	4.4	4.0	4.4	4.2	3.9	4.6
Large N=5	---	4.2	---	---	4.7	---

* One respondent in this category did not complete the section of the questionnaire dealing with familiarity with earth science concepts, making the total number of teachers in the small school size category 32.

schools despite challenging issues such as discipline problems and high dropout rates (Howley, 1997).

Conclusions

This paper discusses the variations in measures of teacher preparation and literacy across high school size classes in North Carolina. For teacher preparation, it was found that the smallest schools had the highest percentage of teachers who had never taken an earth science or related course. In contrast to this finding, teachers surveyed from the largest schools had completed at least four courses in earth science. The majority of the large schools surveyed were found in the SW region of the state, which has the state's largest school district. The data suggests that smaller schools have more difficulty in attracting and retaining more experienced teachers for earth science instruction.

For teacher literacy, it was found that high school earth science teachers have relatively little knowledge of basic geographic concepts, but are quite knowledgeable about the other subject areas included in the study (Environmental Studies, Geology, and Atmospheric Science). The authors believe that a good knowledge of geography is important for teaching earth science. The fact that these teachers recorded low scores in geography has important implications as to the ability of their students to comprehend major concepts in earth science. Teacher literacy did not vary considerably among regions in the state, but teachers from larger schools consistently were more knowledgeable about all the subject areas combined than those from smaller schools. Additional research in the form of a greater number of respondents would generate a larger data set and therefore would provide a more accurate picture of the pattern of both teacher preparation and literacy across school size categories. This would provide for a more definitive conclusion to the research. However, the preliminary findings indicate that school size is an important factor in hiring and retaining teachers with adequate preparation and literacy in earth science. Moreover, the findings suggest that these factors may be at least as significant as more common measures of teaching

effectiveness, such as critical thinking strategies and the use of technology.

Given apparent deficiencies in geographic knowledge by many high school earth science teachers, the issues of preparation and literacy among these educators may be addressed by the establishment of summer workshops at local undergraduate institutions subsidized by state and/or Federal funding. This would help to enhance competency of teachers currently in charge of earth science instruction. A more long-term solution to the problem would be making earth science or a related course a requirement for the state's undergraduate science teacher education programs where no such requirement exists. In programs where the course does exist but is not yet required, the resulting increase in required credit hours would likely translate into better prepared earth science teachers.

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