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Connecting Rural Teachers and Students to Nanoscale Science and Engineering through Teacher Professional Development

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Introduction:

The rapidly developing field of nanoscale science and engineering (NSE) is expected to impact almost every facet of human life and thus has been termed the "next" technical revolution. As stated by Daly and Bryan[1]; "Nanoscale science and engineering represents both the revolutionary and evolutionary nature of science, and if we are to remain contemporary in our curriculum we must design lessons focused in this area and find ways to successfully integrate this content into curricula." However, few teachers have the knowledge to incorporate NSE into their curriculum since this field of knowledge is developing after they have left school themselves. The National Nanotechnology Infrastructure Network (NNIN) is a National Science Foundation funded network of fourteen research institutions that has as one of its goals workforce development in the area of nanoscale science and engineering (NSE). To help meet this goal, NNIN provides teachers and the public with the tools and resources needed to educate the future US workforce in the area of NSE.

Why the need to connect rural teachers and students to NSE? Much research has shown that there is a shortage of qualified U.S. applicants to fill STEM jobs. Even though the high achieving students that are needed to fill these jobs can be found in every geographic area and every race/ethnicity, data shows that talented students from lower income levels are underrepresented[2]. Many teachers and students who live in metro areas are often exposed to high tech jobs and 21st century technologies because these technologies are often in the communities where they live. For teachers and students in rural areas this is not true.

As stated in *Keeping Rural Schools Up to Speed* "Teachers in rural schools need the professional development that will enable them to help their students achieve. However, small rural schools often do not have access to the content expertise that high-quality professional development requires."[3] A study by Glover and Nugent [4] indicate that non-rural teachers may be able to better utilize school/district personnel and have greater access to better conferences and college courses and that rural teachers' best professional development was more often provided in workshop context by regional/state staff members or external consultant. Some studies indicate that nanoscale science and engineering (NSE) can help increase teacher content knowledge and that this can be done not only through face-to-face workshops but through video conferencing and web casting.[5] For this reason NNIN at Georgia Tech feels that research institutions should become involved in professional development in rural areas and especially in the area of NSE.

Work to Date:

Over the past four years NNIN at Georgia Institute of Technology has been working to meet the needs of teachers and students in rural parts of the state of Georgia. The work done by NNIN at Georgia Tech was conducted so that this work could be shared with other universities in the

network. Three Georgia Regional Educational Service Area (RESA) were selected. Table 1 shows the selected RESA areas and some average demographic information for each. As the table indicates these RESA areas have a lower median household income, higher poverty level percentages , a lower percentage of their population completing high school or above, and a lower percentage of their population that has a Bachelor degree or higher degree than the averages for the state of Georgia.

Table 1

RESA	Population (2011)	Median Household Income (2007-2011)	Poverty Level Percentage (2007-2011)	Percentage of population completing High School or above	Percentage of population with Bachelor degrees or higher
Oconee	19516	$33875	22.45%	77.45%	14.41%
Heart of Georgia	16053	$32624	23.29%	76.53%	11.26%
Southwest GA	23918	$34325	26.35%	75.70%	12.52%
State of Georgia Average	Total-9,687,660	$49736	16.5%	84%	27.5%

In previous surveys that have been conducted by NNIN at Georgia Tech teachers stated that some of their concerns with NSE included a lack of knowledge about NSE, unsure how to incorporate NSE into their curriculum, and concern that their students did not have opportunities to learn about current NSE research. Using this information we established the following goals for working with these rural teachers. One goal was to provide teachers with NSE materials, lessons and time for the teachers to find places in their curriculum where these lessons could go. NNIN at Georgia Tech's focus is for teachers to include NSE into the curriculum they are required to teach and not use NSE as an add-on topic. To accomplish this 4 to 5 day face-to-face workshops were conducted with the teachers in the summers of 2010, 2011, and 2012. Even though the goal was to introduce teachers and students to NSE, the specific content for each RESA workshop was determined by the needs of the RESA area. Table 2 below shows the focus NSE content for each RESA area. An example of the NSE content covered in the face-to-face workshop is shown in table 3. The NSE content for workshops was based on the nine big ideas presented in the *Big Ideas of Nanoscale Science and Engineering: A Guidebook for Secondary Teachers*. [6]

The second goal was to establish continuing contact between Georgia Tech and the teachers and between the teachers themselves in the RESA areas. In many rural counties a school may have very few science teachers. Often, there may be only one teacher that teaches a particular science area. In addition many rural areas are not near a research institution. So the second goal was chosen so that teachers would have a way to continue contact with each other and to Georgia Tech. Table 2 below shows the plans that were established for continued contact with teachers.

Table 2

RESA Area	Focus of Workshop	Plan for Continuing Contact
Oconee	NSE and Physical Science: Forces and Electromagnetic Spectrum	Two days of activities were conducted at Georgia Tech and then two days of activities were conducted at Georgia State College and University
Heart of Georgia	Conducting a Nanotechnology Explorations Camp for Students	Teachers were paired up and shared a set of materials that they used to conduct a week-long camp for the students at their home schools. They continue to share the materials between the paired schools.
Southwest Georgia	Big Ideas of Nanoscale Science and Engineering	During summer workshop an online learning community was established through Edmoto which teachers are using throughout 2012-2013 school year, and teachers were shown how to do remote lessons with researchers at Tech. Visits by staff from NNIN to participants' schools were conducted during the 2012-2013 school year.

Table 3

Monday-Size and Scale	Tuesday-Size Dependent Properties	Wednesday-Forces and Interactions; Structure of Matter	Thursday-Tools and Instrumentation; Models and Simulations	Friday-Science, Technology, and Society
Welcome Workshop Pre-survey	Intro to Unique Properties PowerPoint	Mimicking Properties of the Gecko Foot ScSh8, SPS8, SP1	Mitten Challenge	Nanotechnology: A discussion of Ethics S(6,7,8)CS1, S7L4, SB4
Nanotechnology Fact or Fiction S(6,7,8)CS7	NanoDays Balloon Smelling Activity S8P1, S7L2		How Can We See what We cannot See ScSh4,S(6,7,8)SCS4, S(6,7,8)CS5, S(6,7,8)CS9	
Intro to Nano and the Big Ideas PowerPoint	NanoSense UV Lab Sunblock S8P2, S(6,7,8)CS9	Big Ideas at a Very Small Scale S8P1, S(6,7,8)CS8m S(6,7,8)CS9, S6E5, SC6,SPS6		Aerogel and Consumer Products S(6,7,8)CS1, S(6,7,8)CS9, S6E3,
NanoSense Scale of Objects-Lesson 2 ScSh5, S(6,7,8)CS3, S(6,7,8)CS4			Encapsulation S(6,7,8)CS5, S(6,7,8)CS4, S7L2, SPS4, SB1, SC7, SC2, SC7	Well Model S(6,7,8)CS5, S6E3

Evaluations

For the Oconee, Heart of Georgia and Southwest Georgia workshops external evaluators conducted evaluations. Table 4 shows a sample of survey and interview results from these three workshops (Additional data is available).

Table 4

RESA Area	Data Collection Tool	Survey Question	Pre Results	Post Results
Oconee	Survey			Nanotechnology Activities (Scale 1 Not at All 4 Very Much) Informative 3.71 Useful 3.22 Engaged 3.43
	Interviews			"I would spend more days at GT allowing teachers to specialize in an area of interest and really get involved with a situation."
Heart of Georgia	Surveys	Size of a nanometer (1 X 10^{-9})	71% Correct 29% Incorrect	100 % Correct 0% Incorrect
	Interview			"Having access to additional equipment and supplies was wonderful for a small rural school such as ours. We were able to do the same experiments that the students at GT campus do for their camps."
Southwest Georgia	Survey	Select the measurement that is equal to 1 nanometer. 1 X 10^{3} 1 X 10^{-3} 1 X 10^{-9} 1 X 10^{-12} No Clue	81.8% Correct 18.2 Incorrect	100% Correct 0% Incorrect
	Interview			Data currently not available (Available Spring 2013)

Results and Lessons Learned to Date:

Results from the Oconee RESA workshop indicated that the teachers were interested in current research going on at Tech and interested in ways that they could connect their classes to Georgia Tech. For that reason, remote access to Georgia Tech was conducted with the Southwest Georgia Teachers in their workshop during the summer of 2012. One teacher in the SW GA RESA conducted a remote access with a researcher at Georgia Tech during National Chemistry Week in October 2012 and stated that she plans to continue to look for ways to connect with researchers remotely at Tech. Results from the Heart of Georgia RESA showed that materials and supplies provided to the teachers during the professional development program were an important part of teachers conducting nanoscale science lessons in their rural areas. This indicated to us that funding sources for implementing 21st century technologies such as nanoscale science and engineering are important and should be considered when working with rural teachers. When possible, NNIN has participated with other funding sources to provide materials for teachers to use during and after the professional development programs in the summer of 2010 and 2012. This has included lesson implementation funds to buy materials (nitinol, ferrofluid, quantum dots, etc.) to help teachers include NSE in their curriculum. Other results from workshops have included a desire by teachers for NNIN staff to visit their schools. Visits by NNIN staff to schools in each of the RESA areas have occurred since the professional development programs were conducted. Visits usually involve conducting activities with classes.

Several of the workshop teachers expressed a desire for their students to use equipment such as a scanning electron microscope and an atomic force microscope. NNIN staff have taken both

pieces of equipment to two participants' school with two more schools scheduled for April of 2013. During one visit a student used the instruments to scan materials for his science fair project. His teacher was given an USB drive with all the images scanned from the day. The Southwest Georgia RESA teacher professional development is not scheduled to be completed until the spring of 2013. So far some of the lessons learned have included the difficulty in visiting rural schools. The time and distance is significant but the response from the schools visited have been very positive. Often the Ga Tech NNIN staff not only visits with the NSE workshop teacher's classes but other science teachers in the school have asked that their classes also participate. For this reason some visits have been conducted in media centers. Also, currently only two of the participants have not participated in the online learning community that was established through the Edmoto site. The teachers are reading and responding to questions over the *Big Ideas of Nanoscale Science and Engineering* book[6]. They will also be sharing lessons that they have written to incorporate nanoscale science on the site in the spring of 2013. The hope is that this will be a tool for the teachers to stay in contact with each other. Information on the online learning community will be gathered in the spring of 2013.

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