Extending Outreach Success for the National Nanoscale Science and Engineering Centers – A Handbook for Universities

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Abstract

With the creation of the National Nanotechnology Initiative in 2001 and the selection of six outstanding research universities to lead the creation of six National Nanoscale Science and Engineering Centers (NSEC), the opportunity to impact K-12 science curriculum with a new and compelling focus on nanoscience and technology is at hand. However, it is recognized that research scientists are often frustrated in trying to provide information to the K-12 schools to update science and mathematics curriculum. Teachers within those systems are sometimes similarly frustrated. This handbook attempts to provide a framework of the political forces that must be recognized in order to bring about successful changes to curriculum. It defines the groups or communities that impact curriculum in four major categories:

- Operations (teachers, administrative staff, superintendent)
- Policy (local and state boards of education)
- Law (Congress and state legislatures)
- Funding (Local governing bodies, school boards, state legislature, Federal Government)

The roles of each community are explained and some strategies for working with the various elements of each community are given. Five specific recommendations are made for the NSECs and The National Nanotechnology Coordinating Office (NNCO):

- Each NSEC should develop a personal relationship with the people responsible for promulgating national curriculum standards for science and standards for the NSEC's state. NNCO should facilitate at national level.
- Each NSEC should develop clear nanoscience and nanotechnology standards for possible inclusion into next revisions of state and national standards for K-12 science curriculum. NNCO should coordinate development of standards across NSECs so that standards represent a "common voice". (This is for "standards" only – diversity in potential courses to meet those standards is encouraged)
- Each NSEC should develop supporting coursework for nano curriculum standards in conjunction with K-12 teachers.
- Each NSEC and NNCO should present proposed nano standards and coursework to policy-makers and funders whenever possible.
- Each NSEC should work with teacher preparation departments or schools at its participating universities to introduce new K-12 teachers to the nano standards and ideas.

Preamble

Over the years, relationships and collaborations have developed between institutions of higher learning in the United States and the K-12 (Kindergarten through 12th grade) schools. These relationships began with the K-12 schools providing student teaching experiences for future teachers as they completed their college tenure. The launch of Sputnik in the late 1950's generated concern about the state of science and mathematics in the K-12 schools. As a result, a number of university programs were created to bring advanced science and mathematics from the university to the K-12 schools. Over the past forty years these programs have multiplied and developed to the point where there are now numerous relationships between K-12 schools throughout the nation and various universities, federal laboratories, medical facilities, and high technology industries. In 1997, the National Science Foundation (NSF) added "Criterion 2 – Broader Implications" as an additional criterion for evaluating the quality of research proposals submitted by universities. This criterion is often addressed, in part, by proposed interactions with the undergraduate and K-12 communities, with these interactions sometimes referred to as "outreach". The National Nanotechnology Initiative recognizes "Societal Implications" of nanotechnology including the education of future scientists and engineers. Universities have further reached the K-12 community through the creation of collaborations with local museums of science and technology to bring the latest scientific ideas to the general public.

While some students reap the rewards of these interactions and collaborations, many do not because the K-12 systems have not integrated or institutionalized the information as a part of the general curriculum. Many schools have not seen the benefits of these kinds of university programs. The forces that serve as barriers to institutionalization of courses into curriculum impact both traditional courses and electronic distance learning courses. Nanotechnology and nanoscience are concerned with a new and unique set of emerging behaviors of matter – those that are observed at the border of quantum effects or in the 10 nanometer to 100 nanometer distance range. The study of these behaviors is multidisciplinary in nature and can provide a new and exciting basis for a modern science curriculum in both the undergraduate and K-12 systems. Six outstanding research universities have been selected to lead the development of six National Nanoscience Engineering Centers (NSEC). Each NSEC is committed to a program of outreach to K-12 schools. The purpose of this handbook is to provide the university with some insight into the K-12 system so that strategies can be developed to help institutionalize content from the university programs into the general K-12 curriculum for the purpose of serving all the students in a school district, the state, and eventually the nation[1].

The handbook attempts to provide information that is helpful to the NSECs but should be useful to any first-time outreach participant as well as those universities that have had enduring relationships with their local school districts. Following this main section, there are three supporting appendices. Appendix A provides a summary of some of the proposed National Nanoscale Science and Engineering Center (NSEC) outreach programs and is listed by lead university. Appendix B provides some information on

[1] Two examples of "nano-kits" for K-12 that are currently being developed or are available at this writing include one from the University of Wisconsin-Madison (http://www.mrsec.wisc.edu/edetc/index.html) and one from a private company, NanoSonic, Inc of Blacksburg, VA (www.nanosonic.com). This paper focuses on the steps necessary to bring kits such as these to the attention of ALL teachers – that is to make knowledge of nano-level science and technology a part of the curriculum.

distance learning. Some examples of curriculum content standards for a selection of grade levels are in Appendix C.

Background and Introduction

Under the National Nanotechnology Initiative, awards were made to six outstanding research universities for the establishment of Nanoscale Science and Engineering Centers. The universities are Rice, Cornell, Columbia, Harvard, Northwestern, and Rensselaer Polytechnic. In addition to the development of nanoscale science and technology itself, each university proposed an active outreach program to take nanoscience knowledge to the communities outside the research university mainstream. Proposed outreach activities include K-12 teacher institutes, nanotechnology teaching labs, science museum programs, middle and high school curriculum development, high school student programs, and partnerships with Historically Black Colleges and Universities and with women's colleges. Some of these activities are traditional in delivery while other plans incorporate the world wide web for potential distance learning. A more detailed summary of the proposed outreach projects is found in Appendix A and a short piece on distance learning is Appendix B. These outreach activities address Criterion 2,"Broader Impacts" of the National Science Foundation (NSF) Proposal Review Criteria as approved by the National Science Board in 1997 (NSB97-72) and emphasized by the NSF Director in Important Notice 125 – Merit Review Criteria in September of 1999.

Outreach activities can be seen as a positive action to bring together two different cultures – that of research universities and that of the general public and K-12 education (There has been recent discussion in the education community of "K-16" which promotes curriculum thinking to include university undergraduate education as a simple continuation of K-12; however this thinking is still the exception rather than the norm). The cultural differences between the K-12 world and that of the research university make successful implementations of outreach activities anything but assured. A recent Committee of Visitors program review in an NSF division found that review panels regularly treated Criterion 1, "Intellectual Merit", with significantly more weight than criterion 2 in the evaluation of proposals. Reviews of grant reports showed very little consistency in Criterion 2 (outreach) outcomes. If outreach is to be successful in fully integrating the subject technology into the K-12 system, the Principal Investigator (PI) must assure that the cultural differences inherent between the university environment and the general public and K-12 environment are actively and strategically addressed and managed.

It is the intent of this handbook to elucidate some components of the K-12 culture and try to demonstrate how research universities' outreach efforts might achieve the positive effects in four specific areas:

- Communication
- Curriculum Development

- Your Budget (Competing for a teacher's attention)
- K-12 Policy Makers – Who They Are and How to Reach Them

It is recognized that a number of the NSECs and their parent universities already have in place ongoing activities or plans for successful outreach activities with their K-12 communities. This handbook is designed to provide information that can serve to extend the success of current activities with the aim to institutionalize them as an integral part of the science curriculum of the entire school district and, perhaps, even beyond.

Communication

It is easy to characterize the major barrier to communication: K-12 teachers are generally educated and trained in the art and science of teaching, NOT in science itself. When meeting with K-12 faculty, the university must recognize that even the science and mathematics faculty, taken as a whole has very limited subject area background or state-of-the-art/state-of-the-practice capability. For example, a 1993 survey of a large urban school district in Virginia found that while most high school mathematics teachers indicated that they had a major or a degree in mathematics, if held to the requirement that such a degree required 36 semester hours at Calculus level or higher courses, only 22 out of 61 high school teachers met the mark. A national education survey in 1998 found that only 38% of teachers had subject matter degrees. A 1993-94 survey found that nationally 29% of teachers in grades 7 – 12 who teach at least one math course have neither a major or minor in mathematics. Furthermore, the average experience of the teaching force is approximately 15 years, making the last formal work with science or mathematics at a level above what they are teaching somewhat dated. Thus, in working with the K-12 community at-large, there must be a plan to meet them where they are – to begin communications in a language and context that is meaningful to the educated layman, rather than the technical specialist.[2] This is NOT to say that the resulting technology transfer need be marginalized or "dumbed down". It simply states that the beginning of the conversation must be on a level at which both parties can participate and move up in complexity and technical content from there. What the teachers may lack in content area knowledge is more than supplemented by their knowledge of their constituents – the students. The teachers will bring to the university first hand knowledge of the broad set of today's publics that must be brought into the nanotechnology sphere of knowledge.

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[2] While averages are quoted here, sometimes there are one or two teachers in a school district with advanced degrees in content area - some may be carrying out an active research program. Working with them may well transfer technology *to* the system, but even those teachers will have a difficult time integrating the technology *into* the system. The components of such integration are addressed under the headings "Curriculum Development" and "Policy Makers". Identifying and working with teachers of such unique background is very helpful but is not enough on its own to guarantee institutional success.

As one moves away from the school building into the administration buildings and the domains of curriculum supervisors, assistant superintendents, superintendents, and school board members, the probability of detailed content area science knowledge decreases yet further. Of course there are exceptions; a research chemist or biologist may be serving on a local school board or a school administrator may have just finished an advanced degree in a science content area, but the likelihood of these situations is small.

Thus it would be good to have several presentations on nanotechnology and the role that K-12 education can play in bringing this technology and the next generation workforce together. Each presentation should be tested on a trial audience and updated after each use if necessary. For example, a research scientist should have a slightly different presentation planned for each of elementary, middle, or high school teachers. There should be one for business leaders and local governing officials. There should be one tuned to the concerns of school administrators. The roles of each of these groups in assuring success of outreach will be addressed later in the handbook.

Curriculum Development

Many school districts try to provide a wide choice of curriculum options for their diverse student populations. They try to serve the needs of the entire range of students who enter the system: those totally able to read, those who are just ready to read, and those who do not even recognize the existence of letters and numbers. School districts generally strive to use the K-12 years to bring each student to his full potential by offering various tracks in the curriculum continuum. The academic tracks could culminate in Governor's School Programs, the International Baccalaureate Program, Advanced Placement courses, partnerships with local colleges or universities wherein advanced secondary students attend college courses as part of their daily curriculum, or even novel, district-specific courses for which approval from state boards of education have been received. As shown in figure 1, curriculum is the result of the influence of several communities – both internal and external to the school district. There is no national curriculum in the United States. However, national and professional science and mathematics organizations have developed extensive sets of benchmarks and guidelines over the past decade and a half[3].

The NSECs must identify and work with the appropriate K-12 communities to successfully create and integrate new curriculum – perhaps addressing a K-16 continuum. While occasional teacher institutes can be very useful, the participatory

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[3] The American Association for the Advancement of Science (AAAS) published "*Science for All Americans*" in 1989, followed by "*Benchmarks for Science Literacy*" in 1993. Work on these standards continues under the AAAS Project 2061. "Benchmarks" was used extensively by the National Research Council (National Academy of Sciences) to develop the 1996 set of "National Science Education Standards". The National Council of Teachers of Mathematics (NCTM) published a set of mathematics curriculum and evaluation standards in 1989 and a revised set of "*Principles and Standards*" in 2000. These benchmarks and standards serve as references and in an *advisory* capacity for curriculum revisions by the states.

partnering in real curriculum development promises to leave a lasting mark on more students and faculty. It is key to success to put together a coalition of teachers, administrators, students, parents, local citizens, and the university/industry for curriculum development. A study of the current availability of instruction in K-12 regarding even transistors, let alone microelectronics, would be indicative of the gap that must be bridged to teach nanoscience. Even the ideas of quantum physics are the rare exception to high school physics courses, rather than the rule. The U.S. Department of Education supports initiatives by school districts in science and mathematics. However, these initiatives often tend to be developed inside the school districts with little, if any, external input from research quality university faculty. Most often, participation from university schools of education is found. There are exceptions (University of Chicago School Math Program for example) to these rules and the exceptions need to be found and used as models to the extent they are applicable.

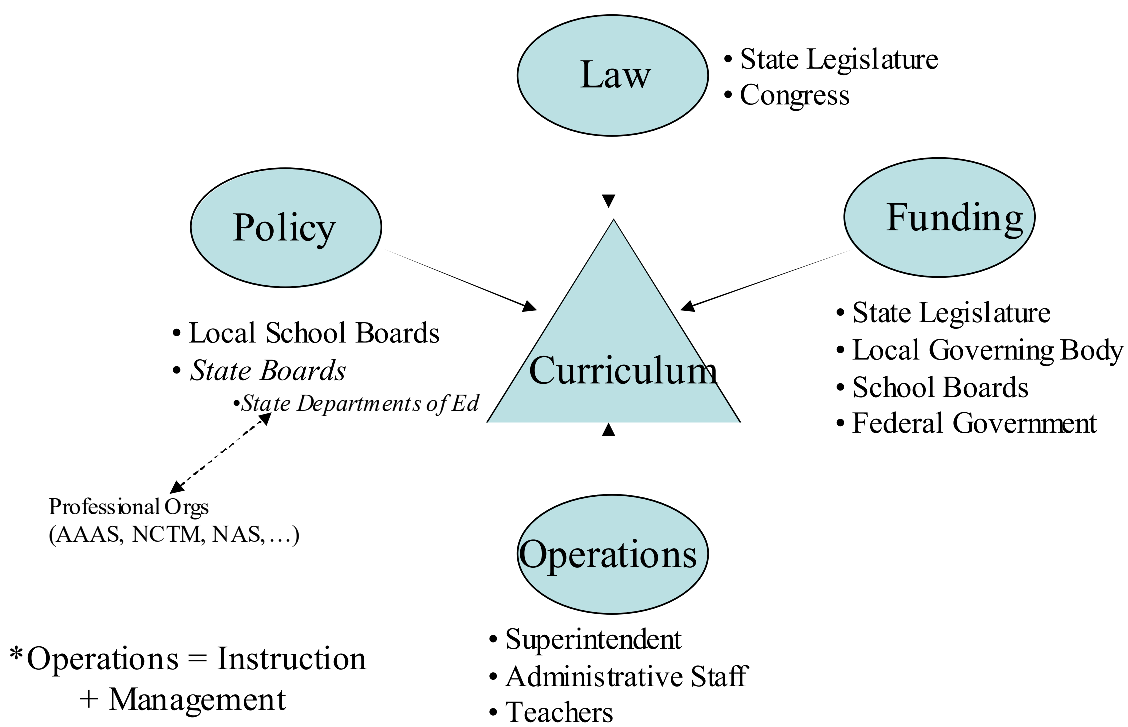


Figure 1 – The Curriculum Communities

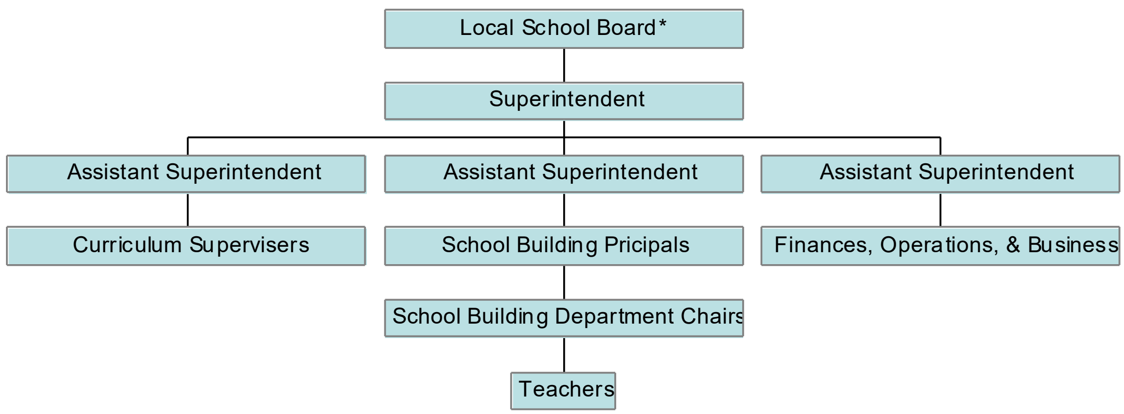
The current curriculum in any school district is the combination of many years impact of the communities and forces in figure 1. Education in the United States is the nominal responsibility of the states in that it is not taken as a Federal responsibility in the United States Constitution. Federal involvement is very limited and has occurred only sporadically since 1776. Such involvement has historically been generated by some perceived crisis and has always had a specific focus. Examples include the Morrill Act of 1882, which led to the establishment of land grant colleges across the

United States to ensure that the advantages of a higher education and the latest techniques of agricultural science and technology would be brought to the vast new lands opening in the West. The Smith-Hughes Act (1917) and George-Barden Act (1946) focused on support for Vocational Education and the Impact Aid laws of 1950 provided local school districts supplements for revenues lost due to a large presence of military facilities that were exempt from the local tax-base. In 1958, the National Defense Education Act (NDEA) was passed to fund science and mathematics curriculum (in addition to research at universities) in light of a perceived crisis in those areas relative to the USSR after the success of Sputnik. Various programs such as the Elementary and Secondary Education Act of 1965 to provide limited targeted federal support for areas such as special education, the poor, and minorities have also developed over the years. However, these federal programs form a very small component of the overall school district operating budget. Nationwide approximately 93% of all K-12 public education support is *non*-federal (44% local, 49% state, 7% federal). That said, federal dollars are very important to school districts that want to examine new ideas or experimental programs. K-12 budgets are extremely inelastic. Approximately eighty to ninety per cent of a school district's operating budget is used for salaries. An unanticipated increase in requirements in a high per capita cost area such as special education can adversely impact a district budget, as can costs for substitute teachers during a year of widespread illness. Because most of their support comes from their states or localities, a downturn in the economy, which leaves states and localities with revenue shortfalls, can have a huge impact on local school districts. Thus, a known and stable amount of federal funding can assure a school district of the necessary resources to carry out a targeted pilot project independent of the uncertainties of their primary funders.

However, funding and a pilot project alone are not enough for assured curriculum development. A *course* might be created but for *curriculum* development, the course must be institutionalized or put into the context of the other courses in the school district. This institutionalization requires the involvement and support of the entire range of communities shown in figure 1. We will now discuss these communities.

<u>Operations</u> – Under school operations, we have put together the faculty, staff, and Superintendent. The closest day-to-day activity between the NSEC and the school district may be with a teacher or group of teachers. Together this pairing can create a technical course (nanotechnology or nanoscience) or module and start to place it properly into the overall science curriculum. However, new courses need to be approved by the district's school board and the placement of such an action on a board meeting agenda rests as a prerogative of the District Superintendent. Figure 2 is a generic organizational chart for local school district governance and management. The Superintendent normally interacts with a curriculum supervisor and an Assistant Superintendent for Instruction or Curriculum regarding these matters. It is better to involve this entire operational sphere from the beginning so as to address their concerns and ideas as the course is developed rather than provide them with a potentially orphaned *fait accompli* after a course is developed.

The Superintendent is usually a fairly savvy political presence, well connected with state legislators, local governing officials, and, often, college and university presidents. The NSEC should make use of any of these relationships to get an audience with the superintendent for the purpose of explaining the NSEC and its intent regarding outreach. This meeting should balance advocacy with inquiry. After making the case for nanotechnology, it is important to get the Superintendent's reaction. He or she may defer until having a chance to meet with some of his or her staff – a participating scientist may be asked to brief the school district staff as part of the process. That is fine. The scientist must be certain, however, to follow up with the designated staff member or, if no name is given, there must be follow up in a couple weeks with the Superintendent as to next steps. The public schools are always busy and items seen as nonessential (nanotechnology curriculum is likely to be one of them) tend to fall off the table.



*Usually Appointed by Local
Governing Body or Locally Elected

Figure 2 – A Generic School District Governance and Management Chart

After a couple of meetings, the NSEC will likely have the support of the superintendent or least his proxy through the engagement of an assistant superintendent, a science supervisor, or a teacher. A leading school district may also have involved other subject area supervisors, indicating recognition of the multidisciplinary implications of nanotechnology. The NSEC can certainly suggest this nature of the area in the earliest discussions with the Superintendent. But remember that K-12 education is stovepiped by content area just as are our universities – after all the teachers and administrators are products of a university.

At this point, a participating scientist may start the technical work in creating the curriculum or may be asked to brief the policy-making body, the local school board, on this exciting new project.

Policy - All policy is made by the local school board. Some is mandated by the state board of education but still must be approved and included in the district policy manual by the local board. A local board's meeting agenda normally contains informational items and action items. The informational items are usually precursors to later actions. They are brought to the board in a public meeting so that the board may take additional public input and engage in open, public discussion. The same material may reappear at the next meeting as an action item for approval. In what may be very frustrating cases to some advocates, approval may take a month or a year or more. In any case the superintendent usually makes a staff recommendation to the board as to whether staff supports the action or not. The earlier meeting(s) with the Superintendent should have cemented his support for potential nanotechnoloogy additions or modifications to the curriculum.

Implicit to board policy, the curriculum is approved by the local school board. The local board normally takes a strategic view of curriculum within the context of serving the local student population and, thus, the future of the community. School districts usually have broad mission statements and goals like many other institutions. New courses must either fit the mission and goals of the district or be so compelling as to cause the board to reconsider the district mission and goals. The local school board is a major player in getting support for new curriculum. Their support will essentially guarantee the proposed new curriculum at least a chance or a pilot year.

The State Board of Education publishes a list of approved courses and textbooks for K-12 schools. However, the State Board or State Department of Education can, upon request, grant a waiver to a local district for the institution of a pilot or test course or program. Unless some very strong ideological or political controversy has engulfed such a course (e.g. creationism, some revisionist history, controversial literature), state approval is very likely for a well thought out pilot program. Some state boards have delegated authority over all elective courses to local boards.

However, a number of states also have implemented or are implementing outcome measures for certain courses. These measures normally take the form of a mandated state-wide standardized test at course completion. Such courses are sometimes known as "verified credits". It is very difficult to add a subject such as nanotechnology to such courses unless that new subject is a part of the outcome measure. The tests for these outcomes are developed and approved at the state board of education level as are the content standards that these tests reflect. **Having a nanotechnology standard as a tested outcome would drive the curriculum to address that standard[4]**.

[4] These tests are becoming the norm across the United States. They are developed separately by each state and have names such as Virginia Standards of Learning (SOL), Texas Essential Knowledge and Skills (TEKS), New York State Regents Examinations, etc. Periodically, a state department of education reviews the content of these standards and tests and makes recommendations for updates to the state board of education. These reviews should include comparing the state standards to various "national" standard and benchmark literature. This consulting role of some national organizations that create the standards and benchmarks is represented by the dashed line in figure 1. Current national benchmark and standards status can be found in references 9, 10, and 11. A concise set of examples of state-level content standards is in

Law (and Funding I) – Some board policies promulgate state or federal law. Examples are policies that prohibit discrimination in hiring or those that mandate a "free appropriate public education be available for all children with disabilities between the ages of three years old and twenty-one years old inclusive". At the state level, school districts can be mandated, by state laws, to carry out certain actions. These mandates can either be "funded" or "unfunded". An unfunded mandate directs the schools to take certain actions but the legislature provides no specific budget to support these actions. A funded mandate directs school districts to take certain actions and the state budget has money included to cover some or all of the expenses associated with these actions. Many district-based educational initiatives are carried out as funded mandates.

The process to achieve such a law and budget often starts with the district developing a list of its budget priorities for its state representatives. The list is prioritized and each element should have a background statement explaining why the initiative is important to the education of the state's children, its intended outcomes, its resource (people, skills, dollars) requirements, and an outcome measurement instrument. Matching funds are often looked upon favorably. A legislator could provide additional funding to the NSECs contribution in this way. At the federal level, science grants from the Department of Education could be leveraged with the NSEC's efforts in a synergistic way. State budget impacts are measured in cycles of a couple of years (fast enough for these NSECs to have impact in their first five-year period). Federal processes are generally slower unless an influential legislator wants to provide an "earmark".

Funding II - Local and state funding make up ninety-three per-cent (93%) of school budgets nation-wide. Local and state officials are more timely and agile than the federal government in their ability to respond to constituent budget needs. While exact rules vary from state to state, the local board has ultimate responsibility for the school budget – how much is spent on various components such as instruction, maintenance, transportation, administration, etc. Funding for the budget comes from a combination of contributions from state legislatures, the federal government, and local revenues. The local revenues are provided either directly from school board taxing authority or from the local governing body's taxing authority. Having representatives in the funding bodies aware of nanotechnology – the what's and why's – is a useful final public component to the curriculum development. It completes the line of authority that starts with the instructional/operational staff so that all elements of the educational process are involved and aware of this new technology, its potential, and how it will be introduced to the children of the school district.

Your Budget (Competing for a teacher's attention)

Appendix C. An example of a nano content standard might be something like: "Students will know three methods for experimentally imaging materials at the nanoscale level and how these methods work."

In working with a local school district, it is always better to bring something more to the table than expertise. What a practicing scientist sees as expertise in the most important area of science, technology, or engineering to come about in 100 years will likely be looked upon by the K-12 community as yet another requirement for their already too crowded schedule and spread-too-thin budget. Thus, bringing expertise and the financial resources to cover the school district's participation in an activity will generally be better received than simply bringing expertise. The NSEC's money must address two issues: 1. Leave the school district no worse off than revenue neutral at the end of the program; and, 2. Attract the best people in the school district to work with the NSEC.

To attract the best people, it is important to remember that K-12 teachers are not generally well-paid. While some senior teachers are paid $65,000 to $80,000 per year in the very top echelon of cities in the U.S., the average teacher salary is $40,000 per year ranging from states with an average of only $28,000 to those with an average of $52,000. Beginning teachers earn from $20,000 to $33,000 per year. These figures are drawn from the 1998-99 school year data from the U.S. Department of Education. Some teachers hold two jobs and many look to employment in the evenings at school sponsored events or during the summer vacation (in school districts that are yet to move to year round schools) to supplement their income. If the Centers are going to involve the best teachers for their programs, they need to successfully compete with other bidders in the teachers' locality. A recent NSF program for Graduate Teaching Fellows in K-12 Education (GK-12) offered graduate students $20,000 per year while offering the teachers who might be involved a maximum of $3,000. The average teacher earns $40,000 for approximately 200 days of work or $200 per day ($1000 per week). Might it be reasonable to set aside an equitable per diem rate for teachers of $1000 per week or $8,000 for an eight-week summer program?

<u>K – 12 Policy Makers: Who They Are and Using Them Effectively</u>

While a bottom-up push is the key to developing the most appropriate curriculum and one that is identifiable by and acceptable to other teachers, the institutionalization of new curriculum can be aided considerably through the interest of the K-12 education policy makers. As discussed under the earlier curriculum development section, policy, educational priorities, and budget for K-12 schools are the responsibility of local boards of education. These boards are advised on educational matters by the district superintendent. The boards also receive advice from local business forums, local elected officials, special interest citizen groups, the general public, student groups, and state and national school board conferences and workshops. Participation through any of these conduits can help ensure budget and priority for institutionalization of nanoscience initiatives.

In particular, a participating scientist can reach a large and broad audience of school board members through participation at state or national school board conferences. Every state has a school board association – usually called simply the Virginia School

Board Association or Texas Association of School Boards and so forth. Some variants such as the Massachusetts Association of School Committees are also found. A listing of these associations and contact points is at http://www.nsba.org/nsbafed/fedmemdir.htm . Regardless of the name, these associations are organized with the idea of serving all the local school boards in the state by providing training, lobbying, and board development. The association can also be a forum for discussion of key issues in education for districts in that state. In addition to the state associations, there is also the National School Boards Association (NSBA). The NSBA is a not-for-profit federation of the state associations of school boards from throughout the United States. Its policies are determined by voting of a 150-member delegate assembly drawn from members of local school boards.

Every year, the NSBA and each of the state associations have large annual conferences or conventions. These conferences can span three to five days and include keynote speakers, workshops on educational issues, small and large panel discussions, and delegate assemblies in which the association policies and positions on educational issues are discussed, voted on and passed. Some examples of state conferences and a very small selection from this year's conference agendas are:

Illinois Association of School Boards
Annual Conference November 16 – 18, 2001 in Chicago

- Creating Academic Success for All Students through Systematic Curriculum Renewal
- Incorporating Outdoor Learning into Elementary and Middle School Curriculum
- Expanding the Curriculum with ON-line Classes (STARnet from Western Illinois University)
- A "Carousel of Panels" – 26 different presentations in the ballroom – pick three for 30 minutes each

Massachusetts Association of School Committees
Annual Conference October 31 – November 2, 2001 at Worcester Centrum Center
(Held jointly with the state association of school superintendents)
Panels include:

- Critical Issues – Curriculum Development
- Technology – Meeting the State's Technology Benchmarks
- Day "On the Hill"

New York State School Boards Association
Annual Convention October 18 – 21 in Buffalo
Educational seminars in Student Achievement and Technology areas include:

- Recognizing and Retaining High Quality Curriculum
- Designing and Delivering Dual Language Programs
- The Virtual School @ Liverpool (on-line and distance learning)

Texas Association of School Boards

Annual Convention September 21 – 24 in Dallas (with Texas Association of School Superintendents)
Agenda includes:

- Science and Mathematics Resources (A half-day workshop)
- PASS – Promoting Academic Success in Science: Is your district's program prepared to meet the challenge of the new state accountability system?

An NSEC could potentially reach virtually every local board member in its state through a presentation at the state boards association's annual conference. Of course such a presentation must be aimed at the audience's level of scientific sophistication and their interest in providing the most relevant curriculum for the future health of their communities. While board members represent virtually all age groups, incomes, educational backgrounds, and ethnicities, a profile of the "average" board member in the United States (1994-95 data from National School Boards Association) is:

- Male (54%)
- College or advanced degree
- Income: 50% earned $40,000 - $79,000/year; 37% earned more than $80,000
- 41 - 50 years old
- 4 years experience on the local board
- White (89%)
- Elected to the position

At the national level, many local boards send representatives to the NSBA Annual Conference. The 2002 conference is scheduled for New Orleans April 6 – 9. Topics include:

- Advanced Broadband Networking: The Real and the Possible
- Challenges and Issues in Distance Education
- Vision for the 21st Century - Using Technology to Involve the Home
- General areas of Staff Development, Governance, Facilities, School Law, 21st Century Issues

For 2001, the NSBA hosted its 15th Annual Technology + Learning Conference November 7 – 10 in Atlanta. Some of the events include:

- On-line Classroom, On-line Community, the Virtual High School (VHS)
- Wichita eSchool: Online Education for K-12 Students
- Breaking Down the Walls: Creating the Millenial Classroom, Genesee Intermediate School District
- Electronic Learning to Prepare Urban Educators, Johns Hopkins University/Center for Technology in Education

Also at the national level is the American Association of School Administrators (AASA). Their annual meeting is in San Diego on February 16 – 19, 2002 with themes such as leading schools and school systems into the future, technology, scheduling, curriculum, charter schools, and home schooling. The Council of Chief State School Officers (**www.ccsso.org**) is a nonprofit nationwide organization which has headquarters in

Washington, DC and is composed of state superintendents of public schools from all 50 states.

A presentation at any of these national conferences would reach a national audience though have much less probability of local impact. The national meetings usually have well known personalities as keynote and plenary speakers, so the competition for board members' and superintendents' attention is keen. Superintendents almost always attend both the state conference and the NSBA conference.

Some Additional Thoughts

Underrepresented minorities, rural districts, and Historically Black Colleges and Universities (HBCUs) – There is a high correlation between underrepresented minorities in science and mathematics and economic disadvantage. Economically disadvantaged K-12 schools as defined through numbers of students receiving free and reduced price lunches (Federal subsidies) were shown to have even fewer teachers with advanced and subject area degrees than the average cited in the earlier section. Thus the NSECs need to be even more mindful of developing effective communication and programs with these institutions.

Point of Contact - Each NSEC must have a point of contact (POC) to develop and manage the implementation plan. This is not necessarily a full time job but must be a priority with the individual rather than a "do as time permits" responsibility. The POC should have technical facility with nanoscience content and be open to understanding the communities that he or she must work with in transferring this relatively high level of technical knowledge out of the university.

Time element to effect a change – Both the university and the K-12 education systems carry huge institutional inertia. It takes persistence, time, and patience to bring about change. The good news is that the NSECs are funded for five years with an opportunity for renewal. Five years is a reasonable time for a focused effort to show results as a model. It may not be enough for the total institutionalization of that model.

Where to Start – If a participating scientist is in doubt as to what school districts might be appropriate partners, who the local superintendents are, or who is on the local school board, the state school boards association (**http://www.nsba.org/nsbafed/fedmemdir.htm)** is an excellent first contact. From their experience in working with school districts and boards from throughout the state, they can help an NSEC find the right people. This contact can also serve as an introduction to some of the people who can put a participating scientist on an agenda for a state conference or workshop later on!

Summary

With the creation of the National Nanotechnology Initiative in 2001 and the selection of six research universities to lead the creation of six National Nanoscience Engineering Centers (NSECs), the opportunity to impact K-12 science curriculum with a new and compelling focus on nanoscience and technology is at hand. However, it is recognized that research scientists are often frustrated in trying to provide information to the K-12 schools to update science and mathematics curriculum. Teachers within those systems are sometimes similarly frustrated. This handbook has provided a framework of the political forces that must be recognized in order to bring about successful changes to curriculum. Groups or communities that impact curriculum were defined in four major categories

- Operations (teachers, administrative staff, superintendent)
- Policy (local and state boards of education)
- Law (Congress and state legislatures)
- Funding (local governing bodies, school boards, state legislature, Federal Government)

The roles of each community were explained and some strategies for working with the various elements of each community were given. Five specific recommendations are made for the NSECs and The National Nanotechnology Coordinating Office (NNCO):

- Each NSEC should develop a personal relationship with the people responsible for promulgating national curriculum standards for science and standards for the NSEC's state. NNCO should facilitate at national level.
- Each NSEC should develop clear nanoscience and nanotechnology standards for possible inclusion into next revisions of state and national standards for K-12 science curriculum. NNCO should coordinate development of standards across NSECs so that standards represent a "common voice". (This is for "standards" only – diversity in potential courses to meet those standards is encouraged)
- Each NSEC should develop supporting coursework for nano curriculum standards in conjunction with K-12 teachers.
- Each NSEC and NNCO should present proposed nano standards and coursework to policy-makers and funders whenever possible.
- Each NSEC should work with teacher preparation departments or schools at its participating universities to introduce new K-12 teachers to the nano standards and ideas.

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APPENDIX A: National Nanoscale Science and Engineering Centers (NSEC) Outreach Summaries – by Lead University

Planned outreach programs and activities that are aimed at K-12, undergraduate, and general audiences are summarized under the name of the lead university of each NSEC. A point of contact is listed for each. Because the NSECs have just recently begun their activities as of this writing, the lists should be viewed as a sample – not an exhaustive compendium for each.

Harvard – Point of Contact is Bob Graham (617.495.4595): Harvard will build on its existing excellent programs and relationships already established through earlier outreach activities. They will integrate nanotechnology modules and content to these programs. These programs include the following:

- Every seventh grader (there are 500) in the Cambridge school district visits Harvard during the year. Each Friday of the academic year 30 to 40 students and three or four teachers attend a day in the life of a Harvard student type of program at the university. The morning is spent in an arts lecture demonstration; lunch is taken in the freshman dining hall; the afternoon is devoted to science lectures and demonstrations. Faculty develop their own lectures and local (Cambridge) Harvard students are used extensively. The idea is to represent college in general as important – not just Harvard. The use of local talent makes the possibility of Harvard more real for these middle school students – they know the Harvard students from the neighborhood. There is good diversity in the Cambridge school population.
- All universities in the NSEC will support the Research Experience for Teachers Program. This program is two years old at Harvard. High school teachers are brought in for four to six weeks in the summer with continuing contact during the academic year. The teachers must commit to two years at the outset. Teachers work in research laboratory with professors, post-docs, or graduate students. Five teachers participated in year one; eight participated in year two. Harvard is looking to grow this program through the addition of nanotechnology research.
- In the GK - 12 program, graduate students go into the schools to work with teachers. The teachers bring their students to the Harvard labs. One of these grad students is paired with a teacher of hearing impaired students in Brighton. These students have visited his biology lab for demonstrations with advanced microscopes that are very visual – a perfect medium for these students.
- Bob Graham knows Cambridge schools superintendent and she strongly supports the Harvard collaborations. He also attends the local mathematics and science teachers associations' meetings.
- There is an undergraduate summer research program that brings undergraduates from other colleges to Harvard. This acts as an intake source for identifying and recruiting future graduate students. They have actively involved underrepresented minorities and a university in Puerto Rico and are going to extend to HBCU's. They intend to use their NSEC international collaborators in this extension.
- A course in which a series of pedagogical lectures are given by local professors and visiting experts from around the country has been offered in some specific

science disciplines. It is planned to develop a similar course under the NSEC and present it and the existing course in alternate years. While the lectures have a large attendance, about ten freshmen take the course for credit. They must develop a paper and lecture on some specific topic covered in the lecture; the paper and talk are graded by the expert who gave the subject talk. This develops writing and speaking skills for the student and gives the student a close personal relationship with an expert in the field.

- Several activities are being coordinated with the Boston Museum of Science. NSEC will participate in lectures and exhibits at the new Current Science and Technology Center in the Center Hall of the museum. The lectures include a question and answer session and tapes of these lectures are carried on the New England Cable Network. Sandia and Oak Ridge (collaborators) also have science museums.

Columbia – Point of Contact is George Flynn (212.854.4162): Columbia will build on its existing excellent programs and relationships already established through earlier outreach activities. They will integrate nanotechnology modules and content to these programs. These programs are basically three years old include the following:

- A Research Experience for Teachers is modeled on the Research Experiences for Undergraduates program. High school and middle school teachers come to Columbia to work in the research labs in the summer. Each commits to two years. About 30 teachers are currently participating. They have meetings of the whole group each Monday with a guest speaker and exchange of information by participants.
- In two existing program areas, graduate students, post docs, and faculty go out to high schools in the New York area to present a one hour lecture/demonstration and interaction. They did a half dozen visits last year. A nanotechnology series will be added to the program.
- In an existing program, a sandtank was developed that could be manufactured for about $2,000 each and used to demonstrate and visualize subsurface water and contaminant flow. A plumeflow software tool has also been developed. Six to ten middle and high school teachers have been trained to use this tank and software. Columbia will develop a similar demonstration project for nanotechnology.
- High school students from Bronx High School of Science come to Columbia to do research under mentorship of post docs and graduate students.

Northwestern – Point of Contact is Kathleen Cook (847.467.5335): The educational mission of the NU-NSEC is to foster a lifelong interest in science and technology by teaching people of all ages about the nano-world. To achieve this goal, they have initiated programs that will ultimately link NU-NSEC scientists and their discoveries to students of all ages and the community at large. These include the following:

- **Research Experience for Teachers (RET) program** –The NU-NSEC partners with Harold Washington College (a member of the Chicago City College Consortium) to provide an innovative two-year program for high school science teachers in the Chicago area beginning in Summer 2002. In the first summer, participating teachers learn more about nanotechnology through active hands-on research with NSEC scientists. During their second summer, participating teachers work collaboratively to fine-tune their ideas and develop them into effective curricular projects. Completed curriculum projects will be presented at local meetings and be available on-line. This program is currently being marketed by direct mail.

- **Science Museum Exhibit** - NSEC researchers are working with the Museum of Science and Industry of Chicago on the development of a conceptual design plan for a unique exhibit on nanoscale science. The exhibit design plan will reflect the Center's research and the Museum's commitment to present captivating, interactive experiences that are memorable and thought provoking. Once complete, the exhibit has the potential to reach more than 2 million annual museum visitors. A designer has been selected to work with the museum and university scientists to create the exhibit, and the kickoff for the project is scheduled for late December 2001.
- **Research Experience for Undergraduates (REU) and the Minority Internships in Nanotechnology (MIN)** – these programs will be initiated in Summer 2002. Participants in both of these programs will perform hands-on research with NSEC scientists for 9-weeks over the summer. Additional workshops, laboratory tours, and events are being planned to broaden the experience. Both programs are currently being marketed nationwide via direct mail and the Internet. Efforts will be made to offer this opportunity to students from smaller schools who do not have access to major scientific equipment, and to female students. The MIN program is marketed specifically to minority students (African-American, Latino, or Hispanic), and promotional efforts are being aided by the Society of Black Engineers and the Society of Hispanic Engineers.
- **Functional Nanostructures Module Program** - Building upon the successful Materials World Module (MWM) program established at Northwestern in 1993, Center researchers have begun the development of a new module that introduces pre-college students to nanotechnology. The completed module or kit will be based on principles of inquiry and design, and emphasize active, hands-on learning. The development team, consisting of teachers, NU professors, and designers, has had several meetings, and preliminary concepts are being tested.
- **Small Business Evaluation and Entrepreneur's (SBEE) Program -** With the emergence of any new high-tech field, including nanotechnology, there will be a substantial number of start-up companies initiated to commercialize the new technological developments. The SBEE program brings NU Kellogg Graduate School of Management students together with scientists to develop appropriate business plans and find necessary funding. This program educates scientists about the intricacies of small businesses, and introduces business students to high-tech developments in nanotechnology.

<u>Rice</u> – Point of Contact is Kevin Ausman (713.348.8212): The Nanoscale Science and Engineering Center at Rice is called the Center for Biological and Environmental Nanotechnology reflecting the focus of the Rice research in this area. The Center takes

advantage of some existing outreach programs by adding nanotechnology to their content but also is developing totally new activities for outreach. The Rice guiding philosophy for their Center is to develop a nanoworkforce for the future with the assumption that in that future, nanoscience will be of the same impact and relevance as polymer science is today. Their programs include the following:

- The 9th grade teacher training project is the newly developed centerpiece of the K – 12 outreach project. It will support between 30 and 16 teachers in each of its phases and is aimed at teachers of a key required high school course in Texas – Integrated Physics and Chemistry. Many students fail this course and drop out of school. The training has three phases:
    - A Spring content course is offered to teachers at night. This course connects concepts required on the Texas standardized test on Integrated Physics and Chemistry with research activities going on in the Rice laboratories.
    - A summer internship for teachers will allow them to work for four weeks in a Center research laboratory directly under researchers to learn the laboratory environment. At the end of he summer, each teacher will create a web page on the specifics they learned. The page will be written at a teachable level of 9th grade.
    - The Fall residency in urban high schools gives the teachers a paid Sabbatical for a semester to develop active learning techniques and practice in a team environment. The use the Model Science Lab that Rice has been operating for 12 years to create these modern tools for interactive teaching for middle school teachers is home to this phase.

- The High School Student Summer Academy brings promising high school students from the Houston area that have been identified by the teachers who are participating in the 9th grade teacher training project into the research labs for the summer to begin individual science projects.
- A Research Experiences for Undergraduates program brings underrepresented minority students from other schools and pays them to participate in a summer research program using the Rice labs and equipment.
- Advanced undergraduate lab courses will be developed in nano areas. These will form half-semester modules for sophomores and juniors in chemistry to do extended lab projects related to nanotechnology.
- Professional's masters degree program would develop an MS that is the actual focus of a program rather than a default degree on the way to a PhD. It will be designed for professionals who are out of the academic environment – maybe for some years – but need additional academic preparation for a new or developing field.
- A weekend workshop on teaching graduate students some of the art and science of teaching is held by the Chemistry Department. Participation in the workshop is required of all teaching assistants.
- Entrepreneurship education is provided for graduate students and post docs through a weekend workshop. The model for nanotechnology will be a "bottom – up" model more like biotechnology with small companies starting up. Business

planning, venture capital, and finance are included in the workshop. In addition an innovative concept forum is hosted in which PI's share their new technologies with prospective investors.

Rensselaer - Point of Contact is Linda Schadler (518-276-2022; schadl@rpi.edu). Schadler is an associate professor in the Materials Science and Engineering Department and has an active research program in nanofilled polymer composites.

- Partnerships with 5 undergraduate institutions (Spelman, Morehouse, Smith, Mt. Holyoke, Williams) have been established. Students will spend the summer after their sophomore year at either RPI or UIUC and then continue their projects at their home institutions jointly advised by faculty from RPI or UIUC and their home institution. The goal is to give undergraduates experience in nanotechnology research and to build bridges to these schools to diversify the graduate population.
- The summer research program will include a team consisting of a High School teacher and several students. They will learn about nanotechnology and develop teaching modules to introduce into the public school system.
- Will develop a program for K-7 at Troy Junior Museum of Science. The Museum has a Digistar planetarium that will be programmed to represent nanoscale views of materials. This will allow the theatre/planetarium to become a large visual simulator of nanoscience phenomena. First visitors will be 1st graders.

Cornell – Point of Contact is Bob Buhrman (607.255.3732): Will expand on programs that have already produced results at Cornell. These existing programs include those that address children who are five to eight years old and their families, afterschool programs for Latino students in which two graduate students have developed lessons in Spanish, and homeschooling modules. There are also extensive Research Experiences for Undergraduates in these Centers.

- Teacher Workshop: This expanded workshop will focus on Physics teachers in the high schools. It addresses the premise that these teachers are isolated both from one another and current developments in Physics. It tries to overcome this isolation through an expanded workshop that includes a 3-week summer institute for 20 teachers. The teachers will create demonstrations in nanoscience and technology during this period. These demos and modules will then be made available to other teachers and one another from a newly created lending library. The aim is to have developed 20 – 30 very good demos over the next 5 years. Cornell has already talked to the high school physics teachers. This program copies a similar one in Biology that has served 200 teachers in the past 5 years.
- Webpages will be created by teachers

"It's a Nano World" will be created for the Ithaca Sciencenter as an exhibit. The exhibit is scheduled for a tour of nine additional U.S. cities before returning to Ithaca.

APPENDIX B: Distance Learning – Complementing and Competing with the Traditional Curriculum

HISTORICAL BACKGROUND

Distance learning can be traced to correspondence courses taken through the mail in the mid and late nineteenth century in both Europe and America. By 1919, the Marine Corps Base at Quantico, VA was employing correspondence course material to teach specific courses and start what was to become the Marine Corps Institute – a distance learning center that still thrives today offering on-line courses. Electronic-distance learning has its roots in radio technology of the 1920's and 1930's as radio stations were established at colleges and universities – often by physics professors as a technological curiosity. By 1938, the Federal Communications Commission had reserved five radio channels to be used for educational broadcasting. Meanwhile, new audio and visual educational media were being developed and used in classrooms. Movies, slides, and filmstrips brought new and interesting materials to the classroom to supplement that found in textbooks. After World War II, television began to make its appearance in the United States and in 1953, the first educational television station, KUHT, began broadcasting in Houston,TX. In 1956, WTTW offered a college credit course via television on its "TV College" program from Chicago. This move from radio to television combined distance learning with the capability for extensive visual media. In 1962, the Congress provided funding for the construction of educational television broadcast facilities. Following a Carnegie Commission study and report (1965 – 1967), the Public Broadcasting Act was passed by Congress to provide additional facilities, establish the Corporation for Public Broadcasting, and fund a study on instructional technology. By the late 1960's and 1970's, colleges and universities used closed circuit and low-power broadcast stations to provide live lectures to students at various locations around the campus, often with an audience of students to ask questions of the instructor at the broadcast studio. These shows were sometimes taped and repeated for students who had conflicts at the live broadcast time or who wanted to review the lecture. Taped lectures on advanced courses were developed at universities and made available to high schools that lacked the expertise to teach such courses. Of course, these taped courses lacked the two-way interaction with the instructor. Local educational television stations provided programming throughout the day to entire communities. In the 1980's, videoconferencing made two-way video and audio instruction in real-time a reality. Teachers and students at two (and later several) locations could see, hear, and interact with one another across a campus, a city, or the country. New technologies did not always supplant the old. So while videoconferencing became available, it's rigid, live scheduling requirements allowed the older, existing videotaped lectures to remain a key part of many curricula. The rapid development of the world wide web, internet, and supporting communications technologies in the 1990's and that continues unabated to today, has presented the distance learning field even further degrees of freedom. Almost instantaneous, worldwide access to on-line courses can be had at anytime of day or night on any day of the week; one needs neither to await a scheduled broadcast nor have a hardcopy of a videotape to participate in the course. Some web-casts are broadcast "live" with interactive question and answer opportunities. While these broadcasts are schedule-constrained, their interactive capability is more widespread than videoconferencing, in that the individual can participate without traveling to a large broadcasting studio.

TODAY

Currently, there are numerous websites associated with distance learning using the computer and internet as the main medium[5]. Other current modes of electronic or e-distance learning involve the familiar teleconferencing, videoconferencing with active 2-way video and audio, or some intermediate combination of the two wherein one might have one-way video or two-way video but with a limited number of participants. There are advantages and disadvantages attached to each of these communication modes. For example, the internet sites are available 24 hours a day/7 days a week to be incorporated at the students' convenience - offering the student maximum schedule flexibility. In offering this flexibility, they do not offer real-time interaction with a teacher to answer questions or, perhaps more importantly, ask directive questions of the student unless the student constrains himself to a live webcast schedule. Video and teleconferencing with a live teacher at one of the nodes offers real-time interaction but is available only on a rigid schedule. Sometimes, tapes of sessions with a live audience are rebroadcast; this approach offers some schedule flexibility and some "passive interaction" in that questions from the students in the live audience are answered. To the extent that they mirror other students' questions and interests, this addresses this drawback of pure web-based sites. The same strategies regarding incorporation of courses into existing traditional curriculum of school districts apply to distance learning courses.

Some web-based information is specifically aimed at moving away from the traditional classroom-based instruction – with a number of sites explicitly focused on providing curriculum for home schooling. "Child U" is such a site. Child U points out that Internet sites are available "24/7" as opposed to school-based education which is provided on its own schedule. A number of people in the education business are starting to embrace this model in that it gives the public the ultimate in choices – choices being a key interest of the public for the past decade. Traditional school infrastructure interests generally oppose this model as it does not fit either their paradigm of education or their means of financial support.

QUALITY AND A SAMPLE OF SOME WEBSITES

Some sites are fairly dated in that they appear to have been one-time funded projects that now stay in place but are not updated. They reside on servers and, in some cases, have pointers to other URL's that are long since discontinued. An example is the Lawerence Berkey Lab (LBL) site that was developed in the mid-nineties in a really excellent effort

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[5] The Netscape browser now has a Distance Learning Decision Guide just as it has decision guides on automobiles and appliances. There are more than 2,200 distance learning programs in its database, fifty-nine of which are catalogued as "science".

to capture students' attention as to the capabilities of IT/computers, provide students with a better than textbook experience in frog dissection/anatomy, and demonstrate how computerized tomography works. A 1995 paper (LBL – 35331) on the project points out some of the lessons learned. The project team decided to reach the high school student by using a frog – standard fare for high school biology – as the subject of virtual lab project (Whole Frog Project). They soon found out that "simple" applications of state of the practice MRI technology to a frog was anything but simple. It seems that the MRI was developed and tuned to mammalian anatomy and the amphibian characteristics were not totally intelligible to it. The MRI results were to be compared with frozen cross section cuts of the subject frog, but even the thin sections that were cut, were too thick to show veins and nerves. Other problems also impacted the project that was done mostly by graduate students with advice from faculty in the areas of medicine, biology, and IT. So the work in progress was put on the web and appears to not have been completed. It gives individual students some ideas as to how to use MRI for developing a geometric model of an object, but gives a less than wonderful experience in frog anatomy when compared with an actual lab experiment. Moreover, the virtual lab does not educate the student on the variability around the average or ideal of real world occurrences – organs that are different sizes, objects running in slightly different places, color ranges, etc). The virtual labs I saw were static – they looked only at the components of an object – not the dynamics of the object or the dynamic interaction of subcomponents. The MRI was aimed at producing a 3-D image of the frog – something better than the flat representation in textbooks. What it seemed to be able to produce at best was something between a textbook representation and a 3-D plastic model.

Variable Quality – Lack of consistency even within sites – Most textbooks are either consistently good, consistently bad, or consistently mediocre. Websites appear to be consistently inconsistent.

NASA has contributed to getting the internet into schools for close to ten years – originally in the HPCC outreach program. These days, NASA laboratories create courses centered on aerospace technology and place them on websites. The courses are nominally built along the skill and specific mission lines of a particular laboratory. The contents vary widely in quality, even within the same site. For example, Dryden Flight Research Center has contracted with Cal Poly – San Luis Obispo since 1997 to create an aerospace based mathematics website. Some of the lessons don't make good sense mathematically (e.g. using latitude and longitude angle differences to illustrate the Pythagorian Theorem). Others are too complex for the general student such as the one on sonic booms and decibels – and it never really connects sonic booms to decibels. There is a module on aerospace vehicle design, but it is no more than pictures and shapes rather than quantitative data or relational data.

Ames Research Center promises us a "Virtual Skies" site in the Fall of 2001. It is advertised to allow the 9 – 12 student to design his own air traffic management system. It will be a "project based learning activity" with hands on multimedia to enhance student decision making and problem solving skills. Topics to be covered include Aviation Navigation, Aviation Weather, Communication Air Traffic Management, Airport Design, and Air Traffic Research. Materials will be tied to the National Standards in Mathematics, Science, Technology, Geography and Language Arts.

A number of professional societies provide “ask the experts” sites or forums. These seem to get some activity from individual teachers and students. Scientific American supports one currently and the author participated in one for the Society of Industrial and Applied Mathematics (SIAM) for a year or so. He received about two dozen questions from high school students, teachers, and college undergraduates over the year.

MARKETING, DISTRIBUTION, AND AWARENESS

The Eisenhower National Clearinghouse (ENC) was set up under funding from the Department of Education’s Office of Educational Research and Improvement in 1997 to identify effective curriculum resources, create high quality professional development materials, and disseminate useful information and products to improve K-12 mathematics and science learning and technology. ENC is physically located at Ohio State University. **Whatever generic material is developed under NNCO Outreach should be made available to the ENC**.

Numerous companies provide teachers and students with access to educational software in mathematics and science. ExploreLearning.com is one of these companies. They are based in Charlottesville VA and have two “subwebsites”: ExploreMath and ExploreScience. These sites provide links to software that ExploreLearning has developed or that they find to be particularly useful. It is free. They also publish e-Textbooks that make extensive use of animation and interactive dynamics. Geoffrey Dixon, founder of the 7stones.com website currently provides material to ExploreLearning. 7stones is a site that has pioneered the use of Shockwave simulations and dynamics to present ideas of science. 7stones was nominated for a “Webby Award”, the internet version of an Emmy, in 2001 under the science category and ExploreLearning was nominated under the education category.

SUMMARY

Distance learning using technology has a long history in the United States. The ubiquitous technology of the world wide web is providing a basis for distance learning to contend with traditional K-12 educational modes for the future standard. Existing distance learning websites are of highly variable quality. Once a website has achieved high quality, it must be consistently maintained and updated to continue as a high quality product. There are several websites devoted to locating and making available useful distance learning programs in science.

APPENDIX C: Examples of Curriculum Content Standards

The following examples of content standards are drawn from Virginia's on-line Standards of Learning Website (http://www.pen.k12.va.us/VDOE/Instruction/wmstds/science.shtml#table) but are generically illustrative of what educators mean when they talk about "standards". They were selected to give the reader some understanding of the language, depth, specificity, and format that educators expect for content standards. These types of standards form the basis for coursework, teaching strategies, and testing. The development and inclusion of nanoscience and nanotechnology standards in a state's accountability testing framework is basic to institutionalizing these areas into school curriculum. These examples are taken from:

- High School Physics
- High School Chemistry
- First Grade Science
- Fifth Grade Science

Physics (High School):

The Physics standards emphasize a more complex understanding of experimentation, the analysis of data, and the use of reasoning and logic to evaluate evidence. The use of mathematics, including algebra, inferential statistics, and trigonometry, is important, but conceptual understanding of physical systems remains a primary concern. Students build on basic physical science principles by exploring in depth the nature and characteristics of energy and its dynamic interaction with matter. Key areas covered by the standards include force and motion, kinetic molecular theory, energy transformations, wave phenomena and the electromagnetic spectrum, light, electricity, fields, and non-Newtonian physics. The standards stress the practical application of physics in other areas of science and technology and how physics affects our world.

Example High School Physics Standard:

PH.14 The student will investigate and understand that extremely large and extremely small quantities are not necessarily described by the same laws as those studied in Newtonian physics. Key concepts include

* wave/particle duality;
* wave properties of matter;
* matter/energy equivalence;
* quantum mechanics and uncertainty;
* relativity;
* nuclear physics;
* solid state physics;
* superconductivity; and
* radioactivity.

Chemistry (High School):

The Chemistry standards are designed to provide students with a detailed understanding of the interaction of matter and energy. This interaction is investigated through the use of laboratory techniques, manipulation of chemical quantities, and problem - solving applications. Scientific methodology will be employed in experimental and analytical investigations, and concepts will be illustrated with practical applications.

Technology including graphing calculators and computers will be employed where feasible. Students will understand and use safety precautions with chemicals and equipment. The standards emphasize qualitative and quantitative study of substances and the changes that occur in them. In meeting the chemistry standards, students will be encouraged to share their ideas, use the language of chemistry, discuss problem - solving techniques, and communicate effectively.

Example High School Chemistry Standard:
CH.2 The student will investigate and understand that the placement of elements on the periodic table is a function of their atomic structure. The periodic table is a tool used for the investigations of
* mass/atomic number;
* isotopes/half-lives/nuclear particles;
* particle/mass charge;
* families/groups;
* series/periods;
* trends/patterns: atomic/nuclear radii, electronegativity, shielding effect;
* electron configurations/oxidation numbers;
* chemical/physical properties; and
* historical/quantum models.

Science Standards of Learning - Grade 1 (Elementary School):

The first-grade standards continue to stress basic science skills in understanding familiar objects and events. Students are expected to begin conducting simple experiments and be responsible for some of the planning. Students are introduced to the concept of classifying plants and animals based on simple characteristics. Emphasis is placed on the relationships among objects and their interactions with one another. Students are expected to know the basic relationships between the sun and Earth and between seasonal changes and plant and animal activities. Students also will begin to develop an understanding of moving objects, simple solutions, and important natural resources.

Example of Grade 1 (Elementary School) Science Standard:
1.2 The student will investigate and understand that moving objects exhibit different kinds of motion. Key concepts include:

objects may have straight, circular, and back and forth motions;
objects vibrate;
pushes or pulls can change the movement of an object; and
the motion of objects may be observed in toys and in playground activities.

<u>Science Standards of Learning - Grade 5 (Elementary School):</u>

The fifth-grade standards emphasize the importance of selecting appropriate instruments for measuring and recording observations. The organization, analysis, and application of data continue to be an important focus of classroom inquiry. Science skills from preceding grades, including questioning, using and validating evidence, and systematic experimentation, are reinforced at this level. Students are introduced to more detailed concepts of sound and light and the tools used for studying them. Key concepts of matter include atoms, molecules, elements, and compounds, and the properties of matter are defined in greater detail. The cellular makeup of organisms and the distinguishing characteristics of groups of organisms are stressed. Students will learn about the characteristics of the oceans and the Earth's changing surface

Two Example Grade 5 (Elementary School) Science Standards:
Matter
5.4 The student will investigate and understand that matter is anything that has mass; takes up space; and occurs as a solid, liquid, or gas. Key concepts include:

- atoms, molecules, elements, and compounds;
- mixtures and solutions; and
- effect of temperature on the states of matter.

Living Systems
5.5 The student will investigate and understand that organisms are made of cells and have distinguishing characteristics. Key concepts include:

- parts of a cell;
- five kingdoms of living things;
- vascular and nonvascular plants; and
- vertebrates and invertebrates.