K-8 Science Program
Review Report
Phase II

Needham Public Schools

June 2007

Introduction

From October 2006 through June 2007, a committee composed of teachers, parents, administrators, the scientific community and the school committee met to:

- Review the viability of curriculum, instruction, and assessment practices in the current program and make recommendations for future directions;
- Assess the Science Center's role with respect to current and future core curriculum and instruction needs; and
- Recommend viable short and long term options for the organization, direction, and funding of the Science Center.

The work of the committee was divided into two phases. ***Phase I*** occurred between October and December 2006. The status of the existing K-8 Science Program was examined with the intent of providing the Superintendent with sufficient information about the existing science program so that he could make an informed, timely decision for the 2007-2008 budget regarding the Science Center and support for science instruction. In ***Phase I,*** students and teachers were surveyed, test scores were examined, focus groups for parents/community members were held, and administrators and Science Center staff were interviewed. Members of the committee toured the Science Center. Parent/community volunteers who were not selected for the committee were invited to participate in a focus group. In January 2007, the K-8 Science Program Review Committee presented its initial findings in a report to the School Committee. The executive summary of the *Phase I* report appears in Appendix A.

Phase ***II*** of the committee's work occurred between January and May 2007. Efforts focused on examining current thinking and practices in K-8 science education with an eye towards shaping the future direction of the district's K-8 science program. In ***Phase II***, the committee hosted presentations from science education experts, researched current literature on best practices in science education, contacted/visited other communities to inquire about their science programs, contacted/visited communities with Science Centers to learn about their programs, held teacher focus groups to discuss various models for science instruction, and distributed a "white paper" (see Appendix C) to a number of practicing scientists, university professors, and heads of scientific related businesses with a request for their comments on the matters we were examining.

Overall Recommendations

Our overall recommendations are based on findings from ***Phase I*** and the overarching themes that emerged in ***Phase II*** of the committee's work. They center on the areas of curriculum, instruction, professional development, leadership, and future directions for the Science Center. The remaining sections of this report summarize the various aspects of the committee's work in *Phase II* and elaborate on the overall findings and recommendations of the K-8 Science Program Review Committee that are listed below.

Curriculum

We would like to see a task force composed of teachers, administrators, and science teacher leaders establish a curriculum that is aligned to the Massachusetts curriculum frameworks and that incorporates the following characteristics:

- Organized, unified and sensible to teach
- Incorporates technology and engineering concepts
- Integrated/ Interdisciplinary
- Teaches scientific method as a means to discovering scientific knowledge.
- Focuses on essential knowledge, understanding & skills that a professional in the field would value.
- Combines scientific content and processes.
- Incorporates a common set of themes and developmentally appropriate skills that spiral through the grades
- Should be "inquiry-based" and "hands-on"
- Addresses preconceptions about science
- Geared to enabling students to become scientifically literate
- Less wide - more deep

Instruction

We feel that science, like math and literacy, is a core subject and it should be viewed as such. We recommend that the district:

- Develop guidelines for the amount of time that should be devoted to teaching science
- Ensure that the number of units taught at each grade level are reasonable in number, easy to teach, and that concepts and skills to be learned can be accomplished within the time allotted
- Provide teachers with time to collaborate regarding the teaching of science

Professional Development

The district needs to ensure that teachers have the knowledge of the science that they teach, how students learn science, and the methods and technologies that support science learning for all students. While critical in all areas, this is particularly important with respect to the engineering and technology now included in the curriculum frameworks. Teachers should have access on a regular basis to a combination of science related courses, workshops, and job-embedded professional development opportunities.

Leadership

Leadership that provides a well-conceived system of curriculum, instruction, professional development, and resources is critical to ensuring and sustaining a vibrant and consistent science program. Having leadership in place also enables programs to be coordinated horizontally and

articulated vertically among the schools and between the grade levels. We, therefore, recommend that the district provide curriculum leadership for science at the elementary level. This can be accomplished by combining curriculum leadership with Science Center leadership to effect greater efficiencies and programmatic coherence.

Science Center

We feel that it is time to formalize the relationship between the Science Center and the science program. Leadership, with the assistance of program specialists, should have a central rather than supportive role with respect to all aspects of curriculum, instruction, assessment, resources, and professional development. We believe that the Science Center should have the flexibility to evolve to fit changing needs and to seek and to develop companion-funding sources for school and community programming.

In addition to providing leadership for the elementary science program, the Science Center should, over time, work towards the development of external relationships that would serve to enhance and extend science-related experiences that are available to teachers, students, and the larger community. External organizations are interested and willing to engage with K-12 science programs. The Center can serve as a clearinghouse to make collaboration as easy and effective as possible for both the schools and groups offering science-related programs. It can act as a buffer to ascertain that the relationships are programmatically relevant, that they run smoothly, and that the dynamics of organizational differences are minimized.

The Science Center offers potential opportunities for increased efficiencies through regional collaboration. Making Science Center resources and professional development programs available to other communities or university schools of education could generate supporting revenue for maintenance and growth of programs. An incremental investment, perhaps generated externally, would likely be necessary to jump start such an effort.

Experts

Phase II began with Jeff Winnokur and Bob Lockhart presenting their thoughts about science education to the committee. Jeff is a Needham parent as well as a researcher, curriculum developer, and teacher trainer at the Center for Science Education at the Education Development Center, Inc. (EDC) in Newton, a research and development organization that has created and markets the Insights science curriculum. He is also associated with Wheelock College in Boston. Bob Lockhart is the long time chair of the Needham High School science department and well-respected member of the Needham High School faculty. We solicited their advice as to the questions we should ask and the factors we should think about as we developed the committee's recommendations with respect to the future directions for the K-8 science program.

With respect to the curriculum, they advised us to consider whether it is: research based; aligned with the Massachusetts standards; balanced (i.e. a mix of content, process, hands-on, wonder); and inquiry-based. They recommended that we ensure that the curriculum spirals content and concepts across the grade levels and that it focuses on depth rather than breath. Both noted that a team of teachers would be the best ones to examine curriculum for these characteristics and to recommend materials for piloting and ultimate adoption.

They advised us to think about pedagogy. A forward-thinking curriculum should be teacher-friendly, thematic, interdisciplinary; developmentally appropriate; and also help teachers to understand what students are thinking and how to channel that thinking into positive learning experiences. The curriculum should include both pre and post assessments for teachers to use.

Planning for implementation was also important. Jeff and Bob urged us to think about initial and recurring costs. The start-up cost of curriculum materials and the replenishment of supplies, materials, technology, as well as on-going professional development should be factored into the cost of adopting a curriculum.

Support structures for the curriculum were also imperative. They advised us to think about science curriculum leadership. Having someone in place to lead the elementary science program is critical to its success. Structures for instruction, professional development, materials management, and for transitions between elementary and middle school are important considerations that require active leadership to maintain a viable program.

With respect to community resources, our experts urged us to consider the relationship between having both internal and external resources in place to support and enhance the delivery of K-8 science instruction. Having the Science Center in place and cultivating relationships between colleges and businesses along with extended day and summer programs are potential ways to maintain a vibrant program.

Research

In examining the literature regarding science education, we looked at standards, trends in science teaching, curriculum planning, best instructional practices, the engagement and motivation of students, ongoing assessment, professional development, and teacher support structures.

Standards

The underlying goal of science standards is to create scientifically literate students. While not all students will become scientists, science education should provide them with a sufficient background to explain natural phenomena and to understand scientific matters that directly affect society. Massachusetts standards are clear, coherent, rigorous, and promote inquiry-based learning. They include depth over breadth and balance content with "doing science." Massachusetts was one of 7 states that have standards that are clear and rigorous enough to earn them a grade of "A." The state has produced an exceptional academic standards document that, if followed in the classroom, would result in excellent science programs.[1] We would do well to make certain that our program is aligned to the Massachusetts curriculum frameworks.

How Children Learn Science

Concepts, facts, and inquiry (in both it intellectual and hands-on aspects) play mutually supportive roles in learning science. Three principles from cognitive and developmental research that can help teachers strengthen their classroom science instruction and increase student learning include:

- Addressing preconceptions and misconceptions students already hold.
- Being certain that teachers and students both understand what it means to "do science." Knowing the roles observation, imagination, and reasoning play and ensuring that processes of science are integrated with the core concepts of science.
- Using metacognitive strategies to help students reflect on their science learning and providing students with a rubric to evaluate their inquiry.[2]

Inquiry-Based Learning

Hands-on inquiry-based science provides a vital conduit for learning science. These experiences, along with such strategies as visual aids and graphic organizers, should be part of the toolkit for teaching students science. More than hands-on science, it is "heads-on" science that incorporates content with prediction and investigation to provide a rich environment for learning science. Through inquiry, students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills.

Infusing Literacy with Science

Embedding literacy with science reading and writing improves student achievement in both literacy and science.[3] Using a model of engaging, explaining, elaborating, and evaluating promotes inquiry-based instruction and encourages students to express, understand, and critique ideas in written and oral forms[4]. It is equally important to note that while using literature to teach science makes some ideas more accessible to students and teachers, it does not replace the need for explicit science instruction.

Professional Development

Effective and well-prepared teachers are key to quality science instruction. Professional development plays an important role in helping teachers to establish a classroom culture of discussion and analysis and promotes active student involvement in investigation. Positive effects on instruction occur after about thirty hours of training. However, a threshold of 80 hours produces optimal results.[5] The professional development must be rooted in the actual science taught, and should include learning about science, about current research on how children learn science, and teaching methods.

Supports/Related Roles of Science Center

In districts that pursue hands-on science—an essential component of standards-based science inquiry—science kits have become more commonplace. While curriculum, not kits, drive instruction, having properly resourced kits readily available that supply the materials for experiments and outline the procedures for the teacher are important to the delivery of a quality learning experience. Material availability and management are key components of a standards-based science program and their importance should not be minimized.

In 1984, the National Science Foundation (NSF) created the Division of Informal Science Education. Since then the NSF has supported informal science education efforts that promote scientific literacy and public understanding of science.[6] There are numerous after-school and summer programs in place across the country that advance science literacy, engage students in scientific experiences and explorations, promote positive attitudes towards science, and increase knowledge about science-related careers. While there is minimal information on the efficacy of many independently run programs, those funded through government grants have found that these programs help to engage students in "doing" science, to change children's attitudes about science, and to reduce stereotypes about scientists.[7] There appear to be significant funding opportunities in this area of programming for children.

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[1] Gross, P. R., Goodenough, U., Lerner, L. S., Haack, S., Schwartz, M., Schwartz, R., et al. (2005). *The state of science standards 2005.* Washington, DC: Thomas B. Fordham Institute. (www.edexcellence.net/institute/publication/publication.cfm?id=352)

[2] Donovan, S., & Bransford, J. B. (Eds.). (2005). *How students learn: Science in the classroom.* Washington, DC: National Academies Press.

[3] Zamach, C.C., Sanders, J., Drake, J.P., et. al. *Infusing reading into science learning.* Education Leadership 64(4), 62-66.

[4] Ansberry, K., & Morgan, E. (2006, January 11). *Picture-perfect science: Using children's books to guide inquiry.* Arlington, VA: National Science Teachers Association.

[5] Banilower, R. R., Boyd, S. E., Pasley, J. D., & Weiss, I. R. (2006 February). *Lessons from a decade of mathematics and science reform.* Arlington, VA: National Science Foundation.

[6] *Educating Americans for the 21st Century: A Plan of Action.* A Report to the American People and the National Science Board (1984).

[7] See http://edequity.org/sgaagenda.pdf for an example of one such program.

Teachers

To examine various ways of organizing science teaching at the elementary level, we assembled teacher focus groups and presented them with several scenarios and asked for comments on each. We probed for what they found exciting about the scenario; how the scenario might improve science instruction; what about the scenario might create difficulties; and what supports they felt were necessary to ensure the success of the scenario.

The scenarios included:

1. A collaborative approach to elementary science in which one teacher is the science "specialist for the grade level. The grade level team can decide to team teach with the specialist, have the specialist deliver science instruction to all classes, or have the specialist oversee the delivery of science instruction at the grade level, offering ideas and coaching to the other grade level teachers.
2. A shared approach to teaching elementary science in which each teacher at a grade level participates in professional development that enables him/her to become the science "expert" in a particular science unit that is taught at his/her grade level. Each unit "expert" assumes responsibility for teaching that unit to all students at his/her grade level.
3. Teaching science in conjunction with literacy in which a model is adopted that provides opportunities for interaction in the classroom, where students carry out investigations and talk and write about their observations of phenomena, their emerging understanding of scientific ideas, and ways to test them. The science lesson is inextricably linked to the literacy activities of the day.
4. A "just-in-time" science co-teaching model in which a master teacher is "on-call" to help plan and co-teach units with classroom teachers or grade level teams.

Teachers felt that each of these scenarios presented many positive possibilities but also had a number of inherent difficulties associated with them. Variations of some of the scenarios were already in place at upper grade levels in some schools and in the right contexts were working quite effectively. Positives were teaching in areas of interest and strength, consistency in curriculum, efficient use of teacher planning time, ease of remaining current with content, and ease of access to experts. The challenges to these alternate models centered primarily on logistics. Scheduling is difficult, need for collaborative planning time and communication, sequencing of topics, and teacher turnover were among the most commonly mentioned obstacles. Regardless of scenario, agreement centered on the importance of having a curriculum with a balanced literacy/science connection, and that instructional models beyond the single classroom were not well suited for students in primary grades. Teachers also reiterated the importance of having a curriculum in place that can be taught within the allotted amount of time. The conclusion we can draw from their responses is that depending on context, teacher background, and logistics, there are many ways to organize for effective science instruction and all rely on having the appropriate amount of time to make it happen.

We also asked groups of elementary, middle and high school teachers, along with Science Center staff about ways children learn science, resources needed for high quality science instruction, critical functions of the science center, and program improvements that could be made. Our teacher/staff focus groups' responses, the advice of the experts, the research and our outside pundits had much in common. A science program that was aligned with the state frameworks, included fewer topics in more depth, topics/concepts that spiraled in developmentally appropriate ways through the grade levels, and instruction that ensured that passion, excitement, and fun are part of the learning experience were all mentioned as important characteristics of a program that would help students to best learn science. Teacher and staff thoughts regarding the supports and structures to have in place for a science program included materials management, professional development, time for teacher collaboration, appropriate instructional time, scheduling to address various instructional scenarios, and reliable up-to-date technology. They also felt that the Science Center should be able to evolve to fit changing curriculum and instructional needs but should continue to be a source of material and instructional support for teachers.

Other Districts

The committee contacted or visited nine[8] other communities to inquire about their science programs and how they organized themselves for science instruction. Communities were selected because they had Science Centers, performed particularly well on the grade five science MCAS test, or because their demographics were similar to those of Needham. We also spoke with staff or visited communities with Science Centers to learn about their centers' relationships to the school science program and about how the centers functioned with respect to programming in the larger community.

Curriculum

All districts were aligned or in the process of aligning their science curriculum to the state standards. The materials used to teach the curriculum in the elementary schools ranged from totally "home grown" to completely commercial. Science kits, whether locally developed or purchased through commercial vendors (e.g. FOSS, Delta, Insights, Pearson Scott Foresman, Project Aries, etc.), were the primary means of curriculum delivery. In a number of instances, commercial kits were embellished with locally developed materials. In some instances vendors for materials were selected on the basis of their match for a particular topic, so that district could have a combination of vendors for particular grade levels and topics. A couple of districts were introducing a science textbook at the fifth grade. In districts with Science Centers, the centers provided management for the curriculum materials.

Units of study were specified at each grade level that incorporate physical, life, earth sciences with inquiry skills and hands-on experiences integrated into the activities. Some of them had engineering and connections to current events or social issues embedded in the units where appropriate. Districts were all working to ensure the curriculum was developmentally appropriate and that concepts and skills spiraled through the grade levels.

Instruction

Science instruction in seven of the districts was the responsibility of the individual classroom teacher. However, two of the districts had different models in place. In one district, the Science Center teachers meet with every class once each week. They introduce a lesson to the class and the classroom teacher is expected to independently conduct the follow up activities. In another district, a teacher from the Science Center jointly teaches the lessons with the classroom teacher.

Professional Development

In districts with science coordinators or specialists in place, teacher professional development was included as part of the responsibilities associated with the position. Professional development was provided on an on-going basis through both individual support and through organized grade level specific workshops or after school courses. Science Centers' roles with respect to professional development varied across the districts and ranged from no role in professional development to providing various after school workshops.

Leadership

All but one of the districts contacted have some form of leadership for science in place for science at the elementary level. The one district without leadership for science has just reviewed its program and has proposed the creation of such a position. Leadership roles ranged from science coordinators, to dedicated mentor science teachers, to science specialists who taught all the science in the elementary schools. In districts with Science Centers, leadership for the science program was either already part of the responsibilities of the teachers who staffed the center or plans are in place for that to happen next year.

The Science Center in Shrewsbury is unique in that it is a regional center dedicated to the support of K-12 Mathematics and Science Education in 133 districts. Funding comes from the University of Massachusetts Medical Center (15%) and from business and foundation grants. Categories of services include: Professional Teacher and Administrator Networks; Professional Development; Mathematics and Science Curriculum Library; and Collaborative materials purchasing. One featured service is "Science-To-Go." This is a centralized replenishment facility for districts implementing hand-on, inquiry-based science programs. They distribute consumable materials in FOSS, STC, and Insights program kits in a cost effective and efficient way. The Shrewsbury Regional Science Center does not offer school wide science programs but does offer a number of community programs for central Massachusetts towns.

Student Achievement

Using MCAS data as a comparison measure (see Appendix B), student achievement in science varied significantly at grade 5 and grade 8 among the districts we contacted. Having a Science Center in place did not appear to impact student science achievement on the MCAS test. Needham has done particularly well on its grade 5 and grade 8 MCAS scores in comparison to other towns with Science Centers. Among all the towns contacted, MCAS scores for Needham grade 5 students fell near the middle, while scores for grade 8 students were highly competitive with similar communities of Winchester, Wellesley, and Dover.

Assessment

About half of the districts contacted had common assessment in place for the units taught at each grade level. The remaining districts had identified it as a need and were in the process of creating them.

External Programming

A number of the districts we contacted that had Science Centers also had summer, after school, or vacation time programs for students. One district is piloting and after school program for students in grades four and five. Another runs an April vacation science program and a summer camp for students. A third community is in the process of developing a space camp for students that is run by the teachers. Some communities without Science Centers ran summer science programs that are sponsored by outside groups or through their community education department.

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[8] Dover, Winchester, Wellesley, Norwood, Burlington, Weymouth, Shrewsbury Regional Science Center, Cambridge, Hudson

Contexts Beyond K-12

To help with envisioning the future K-8 science program and how the Science Center could be positioned to best support the science program and other school and community needs, we sought the advice of experts beyond the K-12 arena. Our intent in doing this was to ensure that the committee's recommendation would not only reflect the best thinking of the K-12 academic community but would also incorporate the knowledge and skills that ensure scientific literacy for our students in the world beyond the K-12 environment. Toward this end, we provided background on (see Appendix C) the efforts of the committee and the issues that were being investigated. We solicited responses to the following three key questions from about thirty members of the Needham community and beyond who had appropriate background and expertise in science-related organizations, businesses, and university departments:

1. Based on your professional experience, what elements do you feel are important to include in a forward thinking science program that is designed to ensure scientific literacy for our students and for the future adult workforce?
2. Thinking of the current workforce, do you see significant gaps in either scientific literacy or science-specific capabilities that may reach back to elementary and secondary education?
3. Would having a Science Center to work with make it more likely that an organization like yours would engage with schools? Which of its roles would be more interesting and relevant for you - hands-on student experience or teacher professional development (or both)? Is a center in a single community of sufficient interest to external organizations to justify their engagement? How much more attractive would a center supporting multiple communities be?

We received responses from eleven of our contacts and a summary of their feedback follows:

Elements to Incorporate in Science Program

Our respondents thought that it was important that our science program incorporate problem solving through inquiry-based learning. They felt that the program should also include technology and engineering components along with an opportunity to learn about science related careers through experiences with practicing professionals. They urged us to enable students to examine scientific concepts within the contexts of real world social issues. A snapshot of their comments with respect to question 1 appears in Appendix D.

Gaps in Current Workforce

Responders identified significant gaps in the current workforce, with respect to either scientific literacy or science-specific capabilities. These gaps include:

- Ability to think spatially
- Problem solving and creativity:
- "Having a general understanding of how to apply different scientific methodologies to understanding systems, and solving new problems."
- "Ability to solve problems via a passion for inquiry, a rigorous approach to approaching a question, and the basic tools of analysis"
- Understanding the potential of simple sustained observation
- Sufficient exposure to science and engineering experiences
- Having confidence in experimenting and trying things out
- Understanding of essential science concepts that enable understanding of current ethical issues or public problems
- Understanding scientific concepts well enough to be able to critically read the news, deliberate on a jury, or to "understand the illness of oneself or one's family member."

Potential Roles for Science Center

Respondents saw the Science Center as a vehicle for interaction with their organizations. Working with the Science Center would make it more likely that outside organizations would engage with schools. A number of people mentioned that their organizations had opportunities for teachers or for classroom experiences, but were unsure of how to go about making the connection with the schools. They also saw a potential for attracting additional resources/funding if the Science Center had connections to multiple communities, but thought its primary mission should be serving Needham. Comments with respect to the role of the Science Center focused on:

External Engagement

- Science Center could be the central point of contact for outside organizations to engage with the schools.
- Science Center could serve as a clearinghouse to help coordinate schools with surrounding university programs, donations of time, equipment, and experiences.
- Science Center could communicate school needs to outside sources.
- Science Center could communicate external opportunities to teachers and students.

Single/Multiple Community Support

- Broader reach is more attractive for connections with external organizations because it provides them with an opportunity to make a difference in multiple communities
- Funding opportunities for a Science Center serving a number of communities might be greater.
- Servicing multiple communities could result in less connection to Needham stakeholders.

A theme that ran through the responses to all three questions was the importance of having well trained science teachers in place. They told us that, "Science teachers at all levels must have a substantial science background and must have a demonstrated zeal for teaching science." In addition to these characteristics, they felt that teachers should have strong pedagogy skills in inquiry-based learning and an understanding of real world applications of science. The Science Center was seen as playing a critical role for ensuring that this happens. They also saw the Science Center as promoting teacher collaboration, sharing effective practices, and co-teaching or modeling effective science instruction in classrooms.

Findings & Recommendations

Our recommendations for standards, curricula, assessment and instruction for the K-8 science program are based upon the current program as outlined in *Phase I* and from common themes found in *Phase II* by outside experts, the research, other school districts and Science Centers, teachers, and the pundits from contexts beyond K-12.

Science standards, curriculum, assessment and instruction—as well as professional development for teachers—should be conceived, designed, and implemented as a coordinated system. Standards and curriculum should lay out specific, clear, and coherent goals for important scientific ideas and practices that can be achieved through sustained instruction over the K-8 school years. The aim should be to help students to develop the knowledge and skills to: know, use, and interpret scientific explanations of the natural world; generate and evaluate scientific evidence and explanations; participate productively in scientific practices and discourse.

Recommendations center on addressing the fundamental questions that were posed at the onset of this program review:

What are the characteristics we would like to see in a science curriculum in the NPS?
What supports/structures are needed to put a science program with these characteristics in place?
What are the critical roles the Science Center needs to play going forward?

Curriculum

While the K-5 science curriculum has served us well in the past, it is dated and needs to be revised. It is not completely aligned with the Massachusetts curriculum frameworks in a number of areas, learning expectations are fairly general in scope, some of the guiding questions have lost their relevance, and some of the units are weak and not age appropriate. The curriculum fails to integrate other subject areas, needs to incorporate technology and engineering concepts and does not spiral concepts and skills through the grades. The K-5, Middle School, and High School science curricula need more horizontal and vertical curriculum coordination.

The schools need a curriculum that prepares students to live in a fast-paced society that values such high level skills like problem solving, ethical decision making, and self-initiative. A successful curriculum both engages students and promotes deep understanding. A well-organized, high quality elementary science curriculum provides students with a solid understanding of important concepts, familiarity with science processes, and an appreciation for the scientific enterprise. To this end, we recommend that the district develop a science task force to address the matters identified by the K-8 Science Program Review Committee and to determine the best way to resource the curriculum that is ultimately developed by this group.

The characteristics that we would like to see in a forward-thinking science program include the following:

- Organized, unified and sensible to teach
- Incorporates technology and engineering concepts
- Integrated/ Interdisciplinary
- Teaches scientific method as a means to discovering scientific knowledge.
- Focuses on essential knowledge, understanding & skills that a professional in the field would value.
- Combines scientific content and processes.
- Incorporates a common set of themes and developmentally appropriate skills that spiral through the grades
- Should be "inquiry-based" and "hands-on"
- Addresses preconceptions about science
- Geared to enabling students to become scientifically literate
- Less wide - more deep

Instruction

Overall, K-8 science instruction is hands-on and inquiry based. Resources are available for teaching the science curriculum either through the Science Center or through the Middle School science department although technology varies from school to school with a particular need quite evident at the Middle School. At the elementary level, the quality, quantity, and importance of science instruction are heavily teacher-specific. Science instruction is inconsistent among and within elementary schools. Instructional time for science is highly variable and in many instances there are questions regarding whether there is adequate time at both the elementary and Middle School level for teaching the existing curriculum. Time for teacher collaboration regarding the teaching of science was a particular concern at the elementary level. For all these reasons, the preparation of 6th graders in science is uneven.

Leadership needs to provide guidelines for the amount of time that should be devoted to teaching science, similar to those already in place for mathematics and literacy. The number of units taught at each grade level should be reasonable in number, easy for teachers to teach, and concepts and skill to be learned should be able to be accomplished within the time allotted.

Instruction should continue to present science as a process of building theories and models using evidence and then testing them empirically. Scientific methodology should continue to be incorporated into the context of pursuing specific questions and issues rather than as a recipe for a process. Inquiry, hands-on and heads-on learning remain mandatory components of instruction. Content and pedagogy to meet students wherever they are in their understanding of science as well as well-equipped labs and updated technology are essential to making make lessons engaging and productive for students.

Professional Development

The Science Center is the primary source for professional development in science for K-5 teachers. This professional development occurs for about three hours, once per year, and is geared to methods and materials that assist teachers to deliver the grade level curricula.

Research tells us that teacher professional development should be focused on developing teachers' knowledge of the science they teach, how students learn science, and specific methods and technologies that support science learning for all students. Positive effects on instruction occur after about thirty hours of training. There is a need to provide sustained content-specific professional development in science on an on-going basis for teachers at each grade level. Particularly important is professional development in areas of engineering and technology that are now part of the curriculum frameworks.

Assessment

Although various assessment practices are occurring in classrooms throughout the district, there are no common grade level assessments or benchmark tests currently in place (other than MCAS at grades 5 and 8) to gauge students' understanding of scientific concepts and skills and the effectiveness of the science curriculum. Commons assessments that provide teachers and students with timely feedback about students' knowledge and that supports teachers' efforts to improve instruction should be an integral part of K-8 curriculum and instructional practices.

Leadership

Uneven science curriculum leadership needs to be addressed, especially in grades K-5. At the Middle School, a Head Teacher provides curriculum leadership for science. There is an urgent need for curriculum leadership for science at the K-5 level as evidenced by the disparities in science curriculum and instruction among the schools and between the levels. Leadership that provides a well-conceived system of curriculum, instruction, professional development, and resources is critical to sustaining a forward-thinking science program. The Science Center does not provide leadership for the K-5 curriculum. Its long-standing mandate has been to support the implementation of the science curriculum rather than to direct the program. Combining curriculum leadership with Science Center leadership would ensure greater programmatic coherence.

Science Center

Over the years, the Science Center has provided extensive support for the K-5 curriculum, instruction, resources, and professional development. Many K-5 teachers have come to rely heavily on Science Center support for their science instruction. However, the science curriculum exists separately from the Science Center. The distinction between the science curriculum and the Science Center was readily evident to the Science Center staff but was not seen in the same way by many teachers and the larger Needham community. These differences in roles and expectations led to a mutual interdependence between the Science Center and the curriculum and resulted in a gap between program ownership and program maintenance. It is time to formalize the relationship between the Science Center, curriculum, instruction, and professional development. The Science Center should be restructured so that its leadership, with the assistance of program specialists, has the responsibility for a forward-thinking science program that ensures:

- Curriculum alignment with MA Frameworks
- Connections to each elementary school to sustain teaching and learning
- Consistency in the delivery of science instruction at K-5 level
- Articulating instructional expectations
- Vertical articulation with middle and high school science leaders
- Sufficient and efficient resource distribution
- Timely and appropriate professional development
- Curriculum integration with other disciplines
- Common assessments that serve to inform instruction
- Central source where materials and lessons can be observed, exchanged, elaborated upon
- Providing students with programs and field trips that excite and engage them in science

Over time, the leadership of the Science Center should work towards the development of external relationships that might include businesses, universities, foundations, etc. that would serve to enhance and extend the experiences available to teachers, students, and the larger community. This may include:

- Using the resources, contacts, materials of the science center to design and deliver high quality enrichment opportunities for students
- Coordinating, endorsing and promoting appropriate outside programs/resources where possible, necessary, and beneficial
- Contributing to its own support through external relationships and thereby supporting the Needham Public Schools' science program
- Establishing greater community visibility and involvement through partnerships for beyond school programs

The Science Center as an organization should have the flexibility to evolve to fit changing needs of the schools and the community. School funding in combination with creative outside partnerships offer significant potential for a vibrant new Science Center that can serve the future of both curriculum and community programming.

Conclusion

Over the last eight months, we have reviewed both the K-8 Science Program and the Science Center with a goal of examining the viability of curriculum, instruction and assessment practices in the current program. We have found that the program in Needham has innumerable strengths. The combined efforts of talented teachers, supportive administrators, engaged parents, and knowledgeable Science Center staff maximizes the resources that are in place to support science instruction. Teachers have a number of opportunities for professional development. Our students enjoy learning science and their Grade 5 and Grade 8 MCAS scores are competitive with comparable communities. There is much in place for which we can be justifiably proud. Nonetheless, we found that the science curriculum is outdated and not completely aligned with the Massachusetts state framework. An updated and aligned curriculum will take best advantage of the many strengths in our educational system.

In the second phase of our work, we learned that teachers, experts, research, and outside pundits are all in agreement regarding the components that a forward-thinking science program needs to have in place and have listed them throughout this report. We agree that planned and thoughtful support structures and resources for teaching science are also critical elements of a vibrant science program and have noted them as well. Most importantly, however, we have learned that we have a valuable, unique resource in the form of our Science Center that we should work to sustain and nurture in new ways that meet the changing needs of the school and community.

Respectfully submitted,
The K-8 Science Program Review Committee

Susan Bonaiuto	Director of Community Education and External Funding
Mark Borowsky	Parent, Eliot School, The Broad Institute of MIT & Harvard
Cathy Clemens	Parent, Pollard & High School, Harvard-Smithsonian Center for Astrophysics
Terry Duggan	Director of Program Development and Implementation
Seth Evans	Grade 5 Teacher, Mitchell School
Michael Greis	School Committee member
Kate Morton	MS Science Teacher
Sharon Pickering	MS Science Lead Teacher
Catherine Prout	K Teacher, Broadmeadow School
Jen Woo Regrut	HS Biology Teacher
Kori Rogers	Parent, Newman School, Fundraising Professional
Anne Schloder	Director, Science Center
Alan Stern	Parent, Hillside School, School Physician
Suzanne Wilcox	Principal, Eliot School

Appendix A

Executive Summary-*Phase I*

There are numerous strengths in our science program, as evidenced by student achievement, parent satisfaction, staff perception, and student perception data. However, there is much room for improvement. The following represents a brief summary of the key findings from each area of our review of the K-8 science program in the Needham Public Schools.

Curriculum

- The K-5 science curriculum needs to be revised.
- The current K-5 curriculum, completed in 1999, is a reflection of the previous curriculum and not aligned with the curriculum frameworks in a number of areas.
- The K-5, Middle School, and High School science curricula need to be more cohesive. There is a real need for horizontal and vertical curriculum coordination.
- Students enjoy the variety of topics in the K-5 curriculum. However, these topics are disconnected from each other
- Over the past year, Middle School science teachers have been working to revise the science curriculum to include an Engineering/Technology component that will hopefully be introduced during the next school year.
- Parent goals for science focused *not* on content, but rather on inquiry-based learning, understanding the scientific process and generating enthusiasm for the subject.
- K-12 Engineering/Technology curriculum needs attention. There should be a K-12 strand and teaching structure in place that augments but does not replace/compete with the science program.

Instruction

- Overall science instruction is hands-on and inquiry based.
- K-5 science instruction is inconsistent among and within elementary schools. Consequently, the preparation of 6th graders in science is highly variable.
- In some instances, K-5 teachers rely on the Science Center for the actual teaching of the science curriculum.
- At some elementary grade levels, lack of adequate time for teaching science and for teacher collaboration regarding the teaching of science was cited as an obstacle. At the Middle School, a number of teachers felt that there were too many units to teach and time for completion was a concern.
- K-5 teachers rely heavily on the Science Center for supplies/materials and instructional support.
- Quality, quantity, and importance of science instruction are heavily teacher-specific at the elementary level.
- For the most part, resources are available for teaching the science curriculum.
- Science instruction is not emphasized as much as reading, writing, and mathematics at the elementary level.

Professional Development

- The Science Center is the primary source for professional development in science for K-5 teachers. Most of the Science Center offerings are focused on introducing teachers to Needham's grade level curricula, demonstrating use of materials, and offering teachers ideas and conceptual foundations that translate directly to classroom science teaching. As a result, the professional development has an immediate impact on the classroom experience for students.
- Through its professional development it increases the quality of K-5 science instruction. The significant number of new teachers that we hire each year creates a need to provide grade level specific professional development in science on an on-going basis.
- A significant number of teachers are requesting content-specific professional development. K-5 teachers would be interested in taking a general science course geared to the elementary level; Middle School teachers are requesting courses in engineering /technology and inquiry-based methodology.

Assessment

- Although the data indicates that various assessment practices are occurring in classrooms throughout the district, there are no common grade level assessments or benchmark tests currently in place (other than MCAS at grades 5 and 8) to gauge students' understanding of scientific concepts and skills.

Leadership

- The Science Center does not provide leadership for the K-5 curriculum. Its long-standing mandate has been to support the implementation of the science curriculum rather than to direct the program.
- There is a need for curriculum leadership for science at the K-5 level as evidenced by the disparities in science curriculum and instruction among the schools and between the levels.

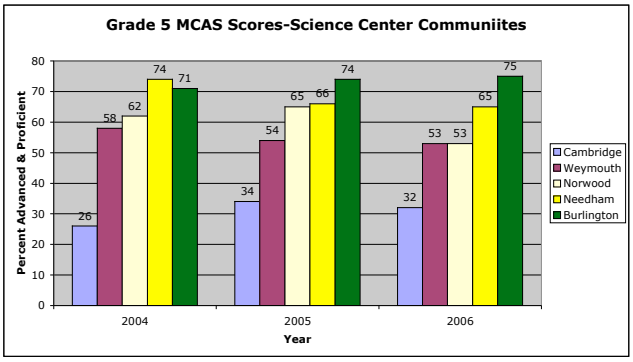
Learning Community

- Middle School science teachers have time devoted to peer observations and collaboration among science grade level teachers, cluster teachers, and science department teachers.
- There is little time for elementary teachers to work collaboratively around science teaching and assessing student science work.

Science Center

- The Science Center is not the K-5 science curriculum.
- The Science Center provides extensive support for the K-5 curriculum, instruction, resources, and professional development.
- Many K-5 teachers rely on Science Center support for their science instruction.
- Parents, teachers, and some administrators expressed concern that without the Science Center, student learning of science would suffer.

Appendix B


Grade 5 MCAS Scores-Science Center Communiites
Percent Advanced & Proficient
Year
2004
2005
2006
Cambridge
Weymouth
Norwood
Needham
Burlington
26
58
62
74
71
34
54
65
66
74
32
53
53
65
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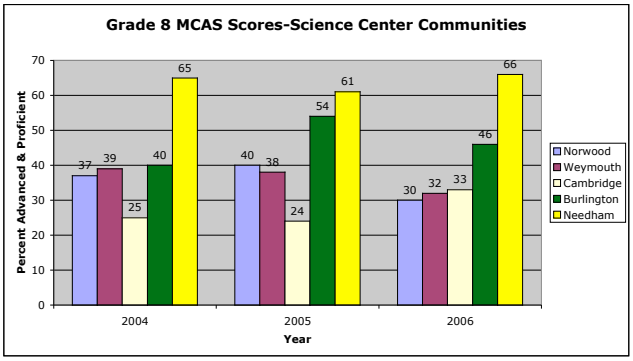
Grade 8 MCAS Scores-Science Center Communities
Percent Advanced & Proficient
Year
2004
2005
2006
Norwood
Weymouth
Cambridge
Burlington
Needham
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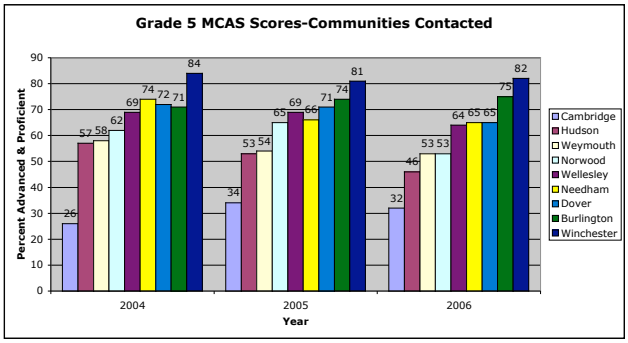
Grade 5 MCAS Scores-Communities Contacted
Percent Advanced & Proficient
Year
2004
2005
2006
Cambridge
Hudson
Weymouth
Norwood
Wellesley
Needham
Dover
Burlington
Winchester
26
57
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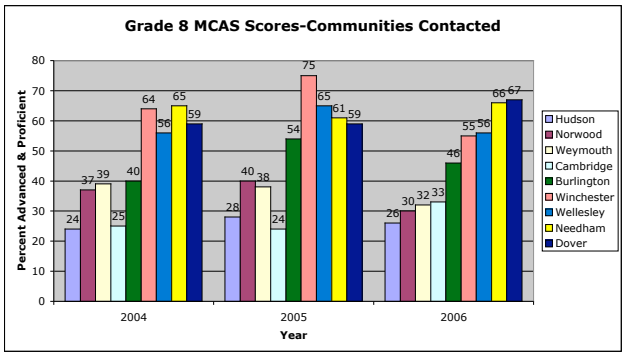
Grade 8 MCAS Scores-Communities Contacted
Percent Advanced & Proficient
Year
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2005
2006
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Norwood
Weymouth
Cambridge
Burlington
Winchester
Wellesley
Needham
Dover
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Appendix C

Needham Public Schools

A school and community partnership that:
creates excited learners • demands excellence • fosters integrity

April 2, 2007

Summary
The Needham schools are redesigning their K-8 science curriculum and defining the future role of the Needham Science Center. We are seeking input from teachers, parents, and science professionals to shape this new curriculum. We are also asking selected leaders in industry and academia to share their vision for an outstanding K-8 science education. We are especially interested in organizations like yours whose success depends on scientifically literate talent - as students, as employees or as customers.

Background
Science education in Needham Public Schools is organized around a ten-year old curriculum and the town Science Center. Although our students perform well on state science tests, we believe it is essential to keep the curriculum up to date and to strive for the best possible science education for our students. Needham's forty-year old Science Center supports the science curriculum by offering a wide range of programs including teacher training workshops, classroom programs, live animal programs, lobby displays, auditorium programs, and field trips. The Science Center also develops, maintains, and loans out science activity/resource kits. At the elementary schools, the Science Center is seen as integral to the science curriculum although the center does not determine the curriculum. The Science Center is also a critical resource for teacher professional development.

The school district is acting on two fronts — ensuring the currency of its science curriculum and re-envisioning the Science Center. In the fall of 2006, a broad-based committee consisting of parents, teachers, and administrators was formed to review the K-8 science program and Science Center role and to make recommendations regarding:

- current curriculum, instruction, and assessment practices;
- future curriculum, instruction, and assessment practices;
- the science center's role in future curriculum development and implementation;
- short and long term organization and funding of the Science Center.

In phase 1 of our work, we examined student science achievement along with curriculum, instruction, assessment, professional development, and leadership practices and found room for improvement in an already excellent science program. A brief summary of this curriculum review is attached. Now, in phase 2 of our work, we are envisioning the future K-8 science program and how the Science Center could be positioned to best support the program along with other school and community needs.

One new role for the Science Center under consideration is to serve as a liaison to organizations outside our school system that have an interest in the quality of primary and secondary science education. The Science Center would continue to be a resource that would enable teachers to provide a high quality, hands-on, inquiry-based science program. Additionally, it would lead and coordinate a network of enriching external science contacts that help produce future scientific leaders.

To make the best possible choices for our revised science curriculum and Science Center, we are soliciting the advice of some members of the Needham community and beyond with appropriate background and expertise.

We ask that you take a few moments to respond to the following questions:

Questions:

1. Based on your professional experience, what elements do you feel are important to include in a forward thinking science program that is designed to ensure scientific literacy for our students and for the future adult workforce?
2. Thinking of the current workforce, do you see significant gaps in either scientific literacy or science-specific capabilities that may reach back to elementary and secondary education?
3. Would having a Science Center to work with make it more likely that an organization like yours would engage with schools? Which of its roles would be more interesting and relevant for you - hands-on student experience or teacher professional development (or both)? Is a center in a single community of sufficient interest to external organizations to justify their engagement? How much more attractive would a center supporting multiple communities be?

Appendix D

Hands-on, Inquiry-based, Problem Solving

- Hands-on, inquiry-based modes (projects, experiments, etc.) are especially appropriate for ensuring scientific and technical literacy
- Understand science as a process
- Allow students the freedom to solve problems at their own rate; avoid protocols and give them the time and materials to figure things out on their own
- De-emphasize memorization and emphasize science as a process
- Teach less detail and spend more time on critically important topics
- Students should be working from problems instead of learning the answers that others already found
- "Present science and technology such that they are not intimidating—keep jargon to a minimum but don't be afraid to teach the students the language they need to communicate and think clearly about science."
- Study science as an interdisciplinary field
- "We should educate our kids to make science both interesting and accessible. We should make science education therefore investigative and hands-on. Science is observational, where children learn from a foundation of collected information to think about possible outcomes (forming hypotheses) and then doing experiments to confirm or invalidate their initial impressions—and then doing it again. The process is empowering—which once mastered allows one to solve problems and think independently for the rest of one's life."

Technology/Engineering

- Focus on science of the natural world as well as the science of the human-engineered world
- Ensure a level of technology literacy-understand the positive and negative aspects of the connected world
- Understand the relationship between science and engineering and integrate engineering into a broader curriculum
- Apply new technologies appropriately to understanding science
- Using modern technology as a vehicle for science education has the potential to make science engaging and relevant.

Real World Relationships

- Teach current topics that are in the news that relate to human health and quality of life
- Incorporate discussions of ethical issues that relate to science
- Provide early experiences that allow students to think and act like scientists and engineers
- Prepare students to be adaptable.