Lexington Public Schools
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To: Dr. Paul Ash
Members of the Lexington School Committee

From: Fran Ludwig
The Science and Technology/Engineering Curriculum Review Committee

Re: **Executive Summary**:
Update on Year One of the Science and Technology/Engineering Curriculum Review

Date: June 3, 2008

As we begin the 21st century, change should be particularly evident in science teaching and learning due to the exponential growth of science knowledge and science-related technologies and increasing demand for graduates who can effectively contribute and use these advances in understanding. When viewed along with an apparent decrease in the number of qualified science teachers that will be available, the pressures on science programs and science education become apparent. Consequently, the science programs of educational systems will need special care and support.
From: Beyond 2000—Teachers of Science Speak Out
A National Science Teachers Association (NSTA) Lead Paper on How All Students Learn Science and the Implications to the Science Education Community
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We are pleased to present a summary of the findings and recommendations from Year One of the Science and Technology/Engineering Curriculum Review of the Lexington Public Schools.

The Science and Technology/Engineering Curriculum Review Committee, with 30 members, consists of representative teachers from each grade and discipline, SPED teachers, and community members including scientists, engineers, science educators, and parents. In addition, Dr. Jacob Foster, the Director of the Office for Mathematics, Science, and Technology/Engineering from the Massachusetts State Department of Education, consulted with us and gave a presentation on the history and future of the Massachusetts Science and Technology/Engineering Framework to the group. We met on August 20 and 21, October 3, January 16 and May 7. Subgroups met in addition to these dates.

The **Goals for Year 1**, as outlined in a document previously shared with the School Committee regarding **all** programmatic reviews, include the following:

- Assemble K-12 content-specific curriculum task forces and study groups.
- Study content-related literature.
- Review most recent Massachusetts Curriculum Frameworks and current local curriculum to determine alignment.
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- Review current resources and materials to determine alignment of curriculum and resources currently being used.
- Review accomplishments or areas of progress in supporting district goals.
- Analyze MCAS and other student performance data to assess strengths and weaknesses of the current curriculum.
- Summarize data analysis.
- Make recommendations for updated curriculum.
- Develop standards-based benchmark outcomes/assessments consistent with revised curriculum.
- Study research-based recommended practices.
- Using specific criteria from curriculum alignment and research-based practices, decide which resources need adjustment/updating.
- Review potential resources and materials that will become part of the new curriculum.
- Identify the appropriate time allotment during the school day for curriculum.
- Begin writing revised, coordinated curriculum, based upon final analysis.

At the end of Year 1, we have accomplished many of these goals. At some grade levels the statement of outcomes/assessments has not been completed, as the revised curriculum has not been developed yet. Also, we are also still researching materials and resources. Additional Year 1 curriculum work will take place in June after the end of classes.

I. <u>The Process</u>

At the summer 2007 meeting the larger committee divided into 3 sub-groups with distinct tasks:
1. Research: Review of literature on science education and Technology/Engineering site visits
2. Assessment: Analysis of student performance (including MCAS)
3. Alignment: Review of local alignment with the <u>Massachusetts Science and Technology/Engineering Framework.</u>

II. <u>The LPS Science and Technology/Engineering Curriculum: A Statement of Purpose</u>

In the 21st century, educated citizens must have a comprehensive knowledge of science and its applications. Our students will be called upon in the future to make informed decisions that will have wide ranging effects on society and our planet.

In order to provide high quality science education in the Lexington Public Schools, the curriculum must meet the highest national standards in core scientific concepts in all disciplines: Biology, Chemistry, Physics, Earth and Space Science, and Technology/Engineering. Lexington students will be taught to apply methods that scientists use to investigate the natural world and that engineers use to create technologies to meet the needs of society. As their skills are developed and their knowledge base is expanded, students will demonstrate the scientific habits of mind: curiosity, open mindedness balanced with skepticism, respect for evidence, persistence, and a sense of environmental stewardship. They will gain both an understanding of science and the ability to apply scientific knowledge as a human enterprise

III. Research and Literature

The following summaries represent areas of research deemed important as we evaluate and revise our curriculum.

Scientific Literacy

"Scientific Literacy means that a person has "the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity." (National Research Council, 1996)

"The National Science Teachers Association identifies the following convictions that must be guidelines as we attempt to facilitate scientific literacy for ALL students:

- Knowledge of the natural and technological world is changing and expanding rapidly as new knowledge is acquired. What teachers of science must learn about and teach to their students is affected by this changing knowledge.
- The knowledge of how students learn science is changing (Bransford et al., 1999) and supported by Pellegrino (2001). ….Facts alone, even if they can be recalled, do not result in the ability to apply information, solve new and complex problems, and retain the knowledge for long periods. The research supports the Piagetian idea that people of all ages construct their own understandings by processing and acting on their experiences. This new knowledge must guide instruction, policies, programs, and practices that affect the development of instructional materials, design of curriculum programs, and programs of assessment in science from preservice throughout their career.
- National Science Education Standards (National Research Council [NRC], 1996) describe the essential science content that all students must have the opportunity to learn and that inquiry provides a context within which the content is to be learned.
- The knowledge of how teachers learn science content, how to facilitate student learning, and how to assess student learning should guide the policies, programs, and practices that establish professional development of teachers of science.
- Professional development of teachers of science is a lifelong process requiring the support of an educational system that is also learning and adapting to new research and technology.
- Support for the lifelong professional development of teachers of science requires the existing systems to adapt and change, provide sufficient funding for professional activities, and seek new structures for professional development."

Learning and Teaching Science

"The National Research Council (1999) published How People Learn, a synthesis of the research on learning. Three of the research findings summarized in the publication have implications for teaching of science in Lexington:

* Engage students beginning with their preconceptions about how the world works.

* To develop competence in an area of inquiry, students must: (a) have deep foundations of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application. Teachers of science must provide their students with inquiries that mentally and physically engage their students with the content, and evidence for it, in ways that facilitate students' understanding as well as provide opportunities for students to apply and transfer their knowledge to new situations.
* A "metacognitive" approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them.

More recently, the National Research Council has issued a report, Taking Science to School: Learning and Teaching Science in Grades K-8 (2007). In it they advocate four strands of scientific proficiency:

1. Knowing, using and interpreting scientific explanations
2. Generating scientific evidence
3. Reflecting on scientific knowledge
4. Participating productively in scientific practices and discourse (inquiry)

In addition, they recommend that the number of science topics in K-8 be reduced to promote greater in-depth teaching and learning. They have begun to identify "learning progressions" to indicate the most important concepts.

Inquiry vs. Content

Inquiry-based science involves students in using the tools of science to answer questions about real-world phenomena. Typically the following skills are developed:

- observing
- asking investigable questions
- designing an investigation
- collecting and interpreting data
- forming conclusions (identifying claims and providing evidence for them)
- communicating
- asking questions

Inquiry-based science may be distinct from "hands-on science" if the hands-on science program is only a series of activities without rigorous content and development of the skills listed above. Scientific inquiry in the classroom can range from open inquiry where students determine the question, materials, procedure and conclusions (science fair type projects) to scaffolded or guided inquiry where the teacher determines one or more of the parameters of the investigation but allows some student choice.

In a debate similar to the "math wars," educators have argued the value of inquiry-based science vs. direct instruction. "In an article in Educational Leadership, Bill Robertson says that science teachers do not have to choose. The way out of this false dichotomy, he says, is the *5-E Learning Cycle ." (Marshall Memo)* In this approach, students experience a combination of open-ended discovery and structured explanation. This is achieved by guiding students through: Engagement (activating prior knowledge), Exploration (use of hands-on materials related to the concept), Explanation, (development of concepts based on results of exploration), and

Elaboration (application of concepts). But the 5E approach is time consuming, if enriching because of its ability to promote scientific thinking. In reality, teachers need to balance instruction between direct instruction and inquiry-based lessons. (Educational Leadership December 2006/January 2007)

Science Curriculum Programs that Support All Students Learning Science (from NSTA)
"Curriculum programs that are well designed and specify what students learn from kindergarten through grade 12 make a difference in student achievement (Schmidt and Valverde, 1999). Effective science programs are multi-year and must include and be based on sound principles of learning and support inquiry-based instruction by teachers of science.

Curriculum analysis from The Third International Mathematics and Science Study indicates that most U.S. curricula lack focus and coherence, two major characteristics of curricula that enhance student achievement (NRC, 1999). Focus is a characteristic that allows students to spend a considerable amount of time on each topic. Coherence requires that science concepts build on previous concepts and experiences, and that ideas are connected to one another in one or more content story lines that weave through a unit, from unit to unit, and from grade level to grade level.

Evidence indicates that with the necessary data, educational systems can and do learn. Thus, a critical requirement for improving K–12 science learning is the presence of a system-wide assessment program that monitors ongoing system improvement and progress. New understandings of how children learn science and how professionals learn to facilitate the child's science learning are changing our view of science teaching."

Reading and Writing to Learn Science
"Inquiry-based science is usually a collective effort in which students record their observations and thinking about an investigable question. They also compare their thinking about evidence and explanations with others' thinking, actively communicate with one another, and express their ideas through words and graphics. Inquiry science and literacy intersect when students use reading, writing and oral language to address questions about science content.

"Informational texts, such as books about science topics, typically communicate about the world beyond the child's home environment. Thus they can play an important role in leveling the playing field for students who have not had access to enriching real-world experiences (Neuman and Celano, 2006). In particular science texts offer many opportunities to expand students' vocabulary, an important benefit because one of the most robust findings regarding literacy is the relationship between vocabulary knowledge and reading achievement (National Reading Panel, 2000). A study on teaching strategies for reading informational text in the science classroom has shown gains in student achievement with modest class time devoted to reading instruction." (Educational Leadership December 2006/January 2007).

Research has demonstrated the benefits of integrating literacy and science in the classroom. The Science Writing Heuristic is a tool to help teachers and students use writing to promote collaborative thinking and reasoning. This heuristic includes guidelines for writing about the steps of inquiry listed above. Middle school studies show that a combination of science writing using the heuristic and the use of textbooks produced the greatest student gains. In 2004 Michael Klentschy reported improvement not only in science knowledge, but in reading comprehension when Science Notebooks were used in conjunction with an elementary kit based science program Many of the students in this study did not speak English as a first language, making the results even more impressive.

All of these findings offer some concrete steps to address the science "achievement gap" in Lexington.

What Students of Science Are to Learn and Understand

National Science Standards

The National Science Education Standards (NSES) (NRC, 1996) and the Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993) provide a description of the essential science content that all students should have the opportunity to learn, understand, and be able to do. In the first half of the 20th century, the emphasis was on the acquisition of skills, information, and the ability to compute with little attention to transfer or problem solving. The NSES and Benchmarks outline science content and stress the development of understanding the science content through inquiry. This inquiry provides the context that includes the students being engaged in many of the same activities and thinking processes as scientists who are seeking to expand human knowledge of the natural world (NRC, 1999). In the NSES the outcomes of science learning contained in the content standards are summarized as the development of the scientifically literate student (NRC, 1996, page 22):

Massachusetts Science and Technology/Engineering Standards

(From a presentation to the review group by Dr. Jacob Foster, Director of the Office for Mathematics, Science, and Technology/Engineering, Massachusetts Department of Education).

Based on the national standards for science mentioned above, teams of educators from Massachusetts wrote the first version of the Massachusetts Science and Technology Framework in 1993. This framework had no engineering standards. Industrial Arts organizations and technology education teachers dictated the technology standards, thus the emphasis on tools and construction.

In the 2001 revision the title became Massachusetts Science and Technology/Engineering Framework, and engineering design* was included as a strand. The intent was to include "technology/engineering" as a core academic subject, rather than to support an industrial arts track. A 2006 revision included minor changes in K-8, and a major reorganization in standards for high school. In this most recent framework there are "first full year course learning standards" for: biology, physical science, introductory physics and technology/engineering.

*The goal of engineering is to solve practical problems through the development or use of technologies, based on the scientific knowledge gained through investigation. The Engineering Design Process involves the following steps:

- Identify the need or problem
- Research the need or problem

- Develop possible solutions
- Select the best solution
- Construct a prototype
- Test and evaluate the prototype (including societal impact and tradeoffs)
- Communicate the solution
- Redesign

In 2008-2009 a review and revision will begin for K-12 Science and Technology/Engineering standards. According to Foster, national standards related to science and technology/engineering that have been published in the last 5 years will be considered as the framework is revised. These national standards include the NOAA climate literacy standards (National Oceanic and Atmospheric Administration), ITEA technology standards, and the NAAEE environmental education standards (North American Association of Environmental Educators). In addition, inquiry standards may be more formal in the future rather than being integrated with content standards, as in the 2006 document. Thus the standards in the current document may change within the next few years.

It is the consensus of the review committee that, although we need to take state standards into consideration, they should not completely drive curriculum decisions. We also need to enlist our experience with students and with the ever-changing content and processes of science and technology/engineering in order to decide what is best for children in Lexington.

Technology/Engineering Education

> Science education should not just be about the natural world, but should also encompass the human made world. " As our society becomes increasingly dependent on engineering and technology, it is more important than ever that everybody should have a basic understanding of what engineers do, and the uses and implications of the technologies they create.
>
> Just as it is important to begin science instruction in the elementary grades by building on children's curiosity about the natural world, it's important to begin engineering instruction in elementary school by building on children's natural inclination to design and build things, and to take things apart to see how they work. At the heart of engineering is an understanding of the *engineering design process*—a highly flexible method of solving problems that is parallel to, but distinct from, the inquiry process in science. (from Engineering is Elementary overview by Dr. Christine Cunningham, Boston Museum of Science)
>
> By middle school and high school, students are ready for more sophisticated challenges in technology/engineering, including a consideration of both the beneficial and harmful impacts of technologies on society.

As part of the research process undertaken by the Science and Technology/Engineering Curriculum Review Committee, a sub-group conducted site visits and interviews in order to identify programs and materials that would support more robust curriculum offerings in technology/engineering in elementary and middle school. (See Appendix VI. for interview questions)

A team consisting of an elementary teacher, two engineers from our committee, and the K-5 Science Coordinator visited the Technology and Engineering Curriculum Review collection at the Boston Museum of Science. We also met with staff from the *Engineering is Elementary* program. Interviews were held with science and K-5 technology/engineering specialists from Newton and Concord. From our investigations and attendance at the National Science Teachers Association National Conference in Boston in March, we concluded that though there are excellent K-5 engineering curriculum choices available from the Museum of Science, other sources such as the WGBH Design Squad also offer lessons that could be integrated into our existing elementary science curriculum. There is general agreement that there is not enough time to add a 20 lesson technology/engineering unit to an already packed schedule. In addition, there are engineering activities that are already embedded in our present science curriculum, but professional development for teachers is necessary for them to be able to identify these as lessons that teach engineering skills.

A middle school team visited B.J. Gray Middle School in Acton and Andover Middle School. Enthusiastic instructors in each of these schools provide a technology/engineering program in dedicated classroom space with appropriate materials and tools. All students participate for one quarter per grade level. Technology/engineering offerings are part of a rotation that includes art and music. Projects include the design, construction, and testing of: planes, soda bottle rockets, etc. As an outcome, students understand the "language of engineering" and enjoy this class. In an interview with the K-8 Science and Technology/Engineering Coordinator in Newton, collaboration between the science department and technology department was described. Newton also has dedicated technology teachers at the middle school level.

Site visits by middle school committee members to Andover and Acton as well as interviews with Newton staff have demonstrated the success of courses dedicated to Technology/Engineering.

In spite of efforts to locate schools where current 6-8 technology/engineering standards are fully addressed through integration within the science curriculum, none has been found so far.
Our middle school representatives judged it difficult to address all middle school technology/engineering standards within the science curriculum.

Since our MCAS data from 2007 shows that technology/engineering questions were answered correctly by 80-90% of our students, the motivation to provide more in-depth experiences in technology/engineering comes from the recognition that these areas will play an important part in the future of our students and possibly inspire career choices in the area of Science, Technology, Engineering or Mathematics (STEM).

IV. Areas of Strength:

In the addenda you will find sample copies of surveys that were administered to all K-12 science teachers. (Appendix II) Note that data from teachers with less than one year of experience in Lexington is not reported. Much of the information on the degree to which our K-12 programs support state standards and on the effectiveness of curriculum implementation comes from these surveys.

Elementary:

Inquiring minds are scientific minds. They ask questions relating to experience with the surrounding world. Whether the questions are phrased as "why?", "when?", "which one?", "how much?", "where?" or "what is the pattern?" there is a method used by scientists to go about determining appropriate answers. Beginning in the earliest grades, Lexington children learn science concepts mostly through direct experience with the natural world. As they mature, students learn how to design scientific investigations to answer questions. By applying science knowledge they learn to solve problems through the engineering design process.

- The Lexington K-5 scope and sequence consists of units of study that provide age appropriate hands-on, minds-on science experiences in the classroom and outdoors. Investigations in Earth Science, Physical Science and Life Science are provided at each grade level.

- Lexington benchmarks for K-5 science are stated and available on the Lexington Public Schools web site

- Overall the elementary science program is aligned with the Massachusetts Science and Technology/Engineering Framework in Earth and Space, Physical and Life Sciences, and in the processes of scientific inquiry. (See Appendix IIIa.)

- Lexington K-5 students consistently score well above the state average in all areas on MCAS tests: Earth and Space Science, Physical Science, Life Science and Technology/Engineering. (see Appendix IV)

- Support for the K-5 science program from the K-5 science coordinator and science materials manager facilitates science instruction at the elementary level. (See Appendix IIIb.)

Middle School:

Students arrive at the middle school inquisitive about the world around them. Their natural science experiences in the elementary grades introduce them to the inquiry models of instruction that they are quickly immersed in when they reach the middle school. The goal of the middle school science program is to continue to foster their enthusiasm for science, teach them to question the world around them, and build a solid conceptual foundation. We aim to develop students who are scientifically literate with problem solving and inquiry skills that will prepare them for higher-level scientific explorations at LHS.

- Curriculum benchmarks for middle school science are available on the Lexington Public School web site.

- Currently the middle school science program is aligned with the Inquiry, Earth and Space, Life, and Physical Science strands of the Massachusetts Science and Technology/Engineering Framework.

- MCAS scores for the middle schools are all well above the state average in all science and technology/engineering topics. (See Appendix IV)

- Professional learning community (PLC) groups at the middle schools are focused on developing common assessments that accompany curriculum maps within the discipline.

- Students participate in many engineering projects in and out of school. School programs include the Science Fair, First Lego League, The MA State Science Olympiad, and Design Engineering Challenges such as projects from A World in Motion. Lexington students consistently rank high in the competitive events.

High School:

The Science Department offers a comprehensive program that satisfies a variety of student interests and needs. For the vast majority of students this includes courses in Earth Science, Biology, Chemistry and Physics. Seniors may also co-enroll in a new semester course – Introduction to Robotics and Engineering.

- Detailed curriculum documents were prepared for all high school science courses during NEASC process. These documents provide both veteran and new teachers with specific guidelines for material to be covered, suggested activities and laboratory experiments, and typical assessments.

- Overall the high school science program is aligned with the Massachusetts Science and Technology/Engineering Framework in the Earth and Space, Physical and Life Sciences. Although all students do not take an Engineering/Technology course, many of the Engineering/Technology standards are addressed informally in Earth Science, Biology, Chemistry and Physics. (See Appendix II Sample for Grade 10 with results)

- Although there is an "opt-out" choice for seniors to graduate with only three years of science, over 97% of the graduating seniors have taken four years of science.

- A .25 FTE Science Study Skills position has been created at the High School and has been staffed by a member of the Science Department. This provides remedial support for students.

- All final exams in multi-section courses are cat least 80% common.

- LHS Students excel on SAT and AP exams. (See Appendix V)

- Science students are extremely competitive in local, statewide and national science competitions (See Appendix V)

V. <u>Areas in need of Improvement/Recommendations</u>:

Elementary

- Comprehensive and cohesive curriculum documents are needed, using the same format as the recently revised mathematics documents, including both state and local standards. There is no current document to show how the K-5 science curriculum topics work to build conceptual knowledge or how they are related from year to year.

- Some teacher guides need revision or replacement. Survey results indicated dissatisfaction with a few specific science units at grades 3 and 5.

- Address areas where significant gaps in alignment with state standards are documented. Analysis of K-5 Science and Technology/Engineering MCAS results has identified concepts that are not effectively addressed by our current curriculum. These include: inherited characteristics, sound, climate vs. weather, and the effect of organisms on their environment. Some of these concepts are too abstract for young children to deal with at the grade level when related content is presented. However they are tested on all of these concepts at a grade 5 level of understanding. (See Appendix IIIa.)

- Strengthen curriculum connections and teacher involvement in the Big Backyard program in order to better integrate these experiences into indoor lessons. Parents need more consistent training. More clarity is needed on the role of this program in the curriculum. (See Appendix IIIc.)

- Develop local assessments for each science unit and redesign the report card to reflect the goals of the science program. There are no system wide common assessments for the Lexington K-5 science curriculum and the current report card evaluates only process, not science content.

- More time must be committed to elementary science. Only 46% of teachers in grades 1-5 agreed that their schedule allowed sufficient time to teach the required science units (18% for Kindergarten agreed that they had enough time). With time dedicated to literacy and math, "left over" time is often used for science. If students need additional instruction in literacy or math, they are frequently pulled from science classes (even though science may provide a strong motivation to learn) and thus they miss opportunities to learn science vocabulary and process. Many of these students score in the "below proficient" category in MCAS. SPED staff has no interaction with the science program. (See survey results in Appendix IV)

- Address the achievement gap. As in English/Language Arts and Mathematics, the percentage of K-8 students below proficient for African American students is significantly higher than it is for white students in these areas. (see MA Department of Education data for percentage of subgroups of students <u>below proficient</u> in Appendix IV)

- Schedule time for K-5 Science professional development in the district wide calendar. There is very little quality professional development time in science for K-5 teachers (1.25 hours per year for most), though teachers say it would be important to them for LPS to offer workshops in science. Many elementary teachers do not have a strong science background, which adds urgency to the need to provide such PD time. Many new teachers have little time for a formal introduction to science units. Though some teachers meet these needs through EDCO, the upcoming district wide schedule does not allow for this level of sustained professional development in science through the LPS. (See preferred workshop topics in Appendix IIIb –

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- Computer technology needs to be updated. Classroom computer hardware is non-existent or outdated in all but the new schools. Software is outdated. Fewer than 30% of teachers K-5 agreed that computer technology met their needs in older schools. Science web sites cannot be accessed in many classrooms because of Mac system 9 limitations. (See Appendix IIIb.)

Middle School:

- Update curriculum documents at each grade level. (the last revision was approximately 8 years ago). Currently curriculum documents are being revised and middle school committee members representing both schools are discussing the science content of grade 6.

- Formalize Technology/Engineering goals and objectives along with the identification of materials for instruction as well as for the infusion of information on science/technology and engineering careers. At the moment there are no stated Lexington benchmarks for Technology/Engineering at the middle schools. MA State technology/engineering standards are used as our guidelines.

- Create a staff position to facilitate the implementation of middle school Technology/Engineering standards. The state clearly considers the technology/engineering standards to comprise a year's worth of curriculum. Guiding Principle I in the Massachusetts Science and Technology/Engineering Curriculum Framework, October 2006 states, in part: "Students in grades 6-8 should have one year of Technology/Engineering education in addition to their three years of science. Schools may choose to offer Technology/Engineering as a semester course in each of two years; as a full-year course in grade 8; or in three units, one each year in grades 6, 7, and 8."

- Address the achievement gap that is represented by MCAS scores at all levels and in all disciplines. (See Appendix IV)

- Writing and reading in the content area is an issue that needs to be addressed. Students have demonstrated that writing scientifically is difficult. Overall Lexington middle school students have performed fairly well on MCAS open response written test items. However, this is an area in which students need support and instruction on how to use scientific vocabulary appropriately. Although we score higher on open response items than the state average, we feel that students should be receiving better scores on the test items. It is evident from the MCAS multiple-choice questions that the students understand the content material. The difficulty seems to arise when students must write scientifically.

- Update textbooks and reference materials including computer hardware, software, and engineering models of instruction.

High School

- Increase time for learning. Reduction in teaching time has impacted curriculum and the richness of the Level 1 and Level 2 science courses. On the high school surveys, over 50% of

Biology teachers noted that the majority of the standards were not being addressed as rigorously at these levels because of the reduction in lab time. Although a smaller percentage of Chemistry and Physics teachers expressed concern over the loss of time, there were several standard specific content areas that were also affected. (See Appendix IIId.)

- Explore possible ways to increase open ended projects/activities within the current schedule. The loss of teaching time for level 1 and 2 courses (AP courses were not affected, as the 6 period schedule was retained) and the focus on content standards has caused a reduction in inquiry based activities, laboratory investigations, the use of open ended questions and coverage of topics not specified in the state standards (such as biotechnology).

- Increase the Science Study Skills position to .5 FTE so all four disciplines are more likely to be covered. Remedial help is needed to support struggling students and students striving to achieve at a high level. Remedial classes would focus on students learning science process as well as science concepts.

- Increase technology/engineering challenge opportunities for physics students. Technology/engineering challenges are not available to all physics students due to reduction in the number of blocks. At this time the recommendation has been made for junior and senior science classes to return to the 6-block schedule to address the 990 hour issue. If this happens then all physics students will have the opportunity to be involved in an engineering design project.

- Wait for 2008 results to interpret LHS MCAS data. Scores for 2007 from the new Grade 10 Biology test are difficult to interpret as this was not a "high risk" test for Lexington students. 2008 tests will determine eligibility for graduation.

- Increased Professional Development and Teacher Training needed:
    - Develop strategies for incorporating writing and math skills into the science curriculum. Research indicates that there is a strong correlation between success in science courses and the strength of math skills. Further, the ability to communicate successfully in science depends on strong writing skills.
    - Provide expanded opportunities for teachers (regular & special education) to deepen their understanding and competency in science content. As teachers of an ever changing and dynamic subject, science teachers need frequent and meaningful professional development

VI. <u>Year Two Goals</u> as outlined in a document previously shared with the School Committee regarding **all** programmatic reviews, include the following:

Curriculum:
- Continue writing revised, coordinated curriculum based upon final data analysis.
- Design and implement interdisciplinary projects (curriculum mapping) wherever possible.
- Determine the use of technology as a learning tool for both students and teachers.
- Decide on pilot or full implementation of new curriculum.
- Project budgetary implications of full implementation of new curriculum.

Professional Development:

- Identify professional development needs to successfully implement new curriculum and train all faculty appropriately.
- Identify continued sustained professional development/consultation to support implementation of new curriculum.
- Share overview program goals of new curriculum with all stakeholders.
- Discuss implementation of new curriculum with task force, grade level teams, and curriculum specialists to share best practices.

VII. Next Steps

There are some common themes in "next steps" across the K-12 spectrum:

- **Develop comprehensive and coherent curriculum documents**
- **Investigate resources for addressing technology/engineering standards**
- **Research strategies for addressing the achievement gap**
- **Integrate literacy and math skills within the science curriculum**
- **Schedule time for science teaching and learning**
- **Develop and schedule time for professional development related to recommendations**

Elementary

- Create curriculum documents for K-5 Science and Technology/Engineering, including state standards and Lexington benchmarks. Adjust existing curriculum where possible and as judged necessary to address "holes" or to replace curriculum units in some cases. Include a Technology/Engineering strand. (Year 2) Curriculum Sub-Committee

- Improve the coherence of the K-5 science curriculum by revisiting concepts over the K-5 time span and showing how ideas are connected to one another in one or more story lines. This will also make review for grade 5 MCAS an easier task.. (Year 2) Curriculum Sub-Committee

- Develop a Technology/Engineering strand for each grade level. Identify existing Engineering/Technology lessons to reduce the need for additional teaching time. Pilot additional Engineering/Technology activities that link to existing units. Include the engineering design process as well as lessons on the application of technologies such as recycling and energy conservation. (Year 2.) Technology/Engineering Sub-Committee

- Pilot lessons and/or units that improve alignment with state standards, provide greater teacher support, or are more effective. Grade 3 and 5 teachers. Year 2.

- Plan and schedule professional development to update teachers on curriculum changes (including the Technology/Engineering strand), and to develop competency in content knowledge. This is an essential component of curriculum renewal. Challenge Professional Learning Communities to choose a topic related to literacy and science or mathematics and science. (Year 2)

- Organize a collaboration between classroom teachers, the K-5 science coordinator and reading specialists to develop reading lessons using non-fiction books from the classroom science libraries. Linking the literacy skills of reading, writing and discourse to science learning provide for maximum impact in minimum time, thus helping to address the time issue. Research non-fiction titles that are appropriate for a variety of reading levels and the science unit topics. (Year 2) Science and Literacy Workshops.

- Address the achievement gap in science and technology/engineering. Investigate the degree to which vocabulary, reading and writing impact science learning. Work with E/LA and SPED specialists to determine how the science curriculum can better adapt instruction in these areas. (Year 2). Possible PLC topic.

- Participate in a study group to develop realistic time requirements for daily elementary schedules. This would include principals, teachers, and specialists in all subject areas. Such a group has not convened for a number of years. System wide

- Revise report cards to reflect process and content balance in the K-5 science curriculum. Participate in a system wide report card committee. System wide

Middle School

- Revise and update the middle school science curriculum with particular focus on articulating various models of inquiry, climate literacy and solidifying the sixth grade scope and sequence. The need to develop current curriculum documents and updated LPS benchmarks is essential. This process has begun and will continue with a June 2008 workshop comprised of review committee members from both middle schools. (Year 1 and 2)

- Integrate objectives into the curriculum that formally address reading and writing in science. The need to develop strategies that address these objectives will be necessary as curriculum documents develop. PD may be needed in this area. This concern can be addressed by the formation of a sub-group within the middle school science committee members that specifically focus on promoting reading and writing instruction within the curriculum. (Year 2).

- Develop small group remedial interventions in science to close the achievement gap. This will require additional staffing, similar to the math intervention program and specialists that have been instituted in the middle schools this past year. (Year 2)

- Investigate and develop the most appropriate and effective way to address state Technology/Engineering standards. This may include creating a dedicated course that will address the goals and objectives of the Massachusetts Technology/Engineering framework. Additional staffing and materials will be required for a dedicated Technology/Engineering course. The formation of a sub-group to draft a proposal for this dedicated course would be necessary. (Year 2)

- Provide professional development focused on exploring STEM opportunities that promote

Technology/Engineering literacy. Other related PD programs should also include: The Museum Institute for Teaching Science (MITS), The Museum of Science (MOS), and National Center for Technological Literacy (NCTL). Release time for committee members will be needed to explore options available in addition to funds for conferences and pilot programs. (Year 2)

- Recommend a budget for purchasing texts, references, computer hardware, software & new innovations for teaching Science, Technology and Engineering. (Year 2)

- Schedule time on the district calendar to meet with elementary, middle, and high school coordinators to articulate the K-12 science program. (Year 2)

High School

- Review 2008 Biology MCAS data when available. This will be the first "high stakes" MCAS test in science. Biology teachers will need to meet in late fall of 2008 to assess the need for possible changes in the curriculum coverage and presentation. (Year 2)

- During 2008-2009 a curriculum team (one from each discipline) will explore available research on the correlation between math skills and performance in science. The team will develop activities to increase math activities within each curriculum. (Year 2)

- Examine and refine level 2 Biology to improve student participation and knowledge by increasing formative assessment and using a personal response system. June and summer 2008 (Years 1 and 2)

- Teachers develop open-ended projects/activities for each discipline (excluding science fair). Form a committee of teachers, at least one from each discipline, to investigate the feasibility of introducing more open-ended activities into the curricula. This can be done during the2008-2009 curriculum meetings. (Year 2)

- Research available programs for developing science writing skills (Year 2)

We thank you for your support for the Science and Technology/Engineering program of the Lexington Public Schools. Through our work in this curriculum review process, our goal is to find more effective ways to achieve our objective of scientific and technological literacy for all of our students.

5/26/08

Science and Technology/Engineering Curriculum Review

Update on **Year One** of the

Science and Technology/Engineering

Curriculum Review

Lexington Public Schools

June 3, 2008

The Process

- Goals for Year One
- Mission
- Work of Sub-groups
  1. Research:
     a. Science Education;
     b. Technology/Engineering Programs
  2. Analysis of Student Assessment (MA and national)
  3. Review of Local K-12 Curriculum Alignment and Implementation of Curriculum
- Areas of Strength and Areas Needing Improvement
- Year Two Goals and Recommendations

Goals - Year 1

- Assemble K-12 task force & study groups.
- Study content-related literature.
- Review Massachusetts Curriculum Frameworks and current local curriculum to determine alignment.
- Review current resources and materials to determine alignment.
- Analyze MCAS and other student performance data to assess strengths and weaknesses of the current curriculum.
- Summarize data analysis.
- Make recommendations for updated curriculum.

Goals Year One (cont.)

- Develop standards-based benchmark outcomes/assessments consistent with revised curriculum.
- Study research-based recommended practices.
- Use data analysis, curriculum alignment & information on best practices to make recommendations for updating curriculum.
- Begin writing revised, coordinated curriculum, based upon final analysis.

Science and Technology/Engineering Mission Statement

Educated citizens must have a comprehensive knowledge of science and its applications.

Lexington Public Schools must provide a high quality science education :

- Content: Biology, Chemistry, Physics, Earth and Space Science, Technology/Engineering
- Skills: Science inquiry and engineering design

Research Findings

Scientific Literacy means that a person has:

"the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity." (National Research Council, 1996)

Research Findings (cont.)

Teaching and Learning

- Engage students beginning with their preconceptions
- Competence comes from:
  -- understanding facts and ideas in the context of an organized conceptual framework
  -- organizing knowledge in ways that facilitate retrieval and application
  -- participating in scientific practices and discourse

From: How People Learn National Research Council 1999, Taking Science to School, Learning and Teaching Science in K-8 National Research Council 2007

Research Findings (cont.)

Science Learning Standards

National Science Education Standards (1996)

* Science as Inquiry
* Physical Science
* Life Science
* Earth and Space Science
* Science and Technology
* Science in Personal and Social Perspectives
* History and Nature of Science

Research Findings (cont.)

MA Standards/MCAS Topics - 2006

- Life Science
- Physical Science
- Earth and Space Science
- Technology/Engineering

Research Findings (cont.)

Engineering Design Process

- Research problem
- Develop possible solutions
- Select best solution
- Construct prototype
- Test and evaluate prototype
- Communicate solution
- Redesign

Areas of Strength

Elementary

- Scope and sequence age appropriate, hands-on, minds-on experiences
- Aligned with MA standards in Life, Physical, and Earth and Space Science
- Students score well above state average on Grade 5 MCAS in all areas
- Support from K-5 Coordinator and Materials Manager

Areas of Strength

Middle School

- Curriculum aligned with state standards for Inquiry, Life, Physical, and Earth and Space Sciences
- MCAS scores well above state average in all areas
- Common assessments are being developed (PLC)
- Science and engineering projects in and outside of classroom

Areas of Strength

High School

- Comprehensive program: Earth Science, Biology, Chemistry, Physics
- Overall alignment with MA standards
- 97% of graduating seniors take 4 years of science
- Detailed curriculum documents
- Students excel in SAT II and AP scores, and in science and engineering competitions

Other Notable Information

- Middle and High School teams have excelled in regional, state, and national competitions
- Individuals have received exceptional recognition for science successes

Areas in Need of Improvement
K-12

- Curriculum documents need to be comprehensive, coherent, articulated
- Role of Technology/Engineering needs to be defined
- More time needed at all levels to fully address standards and for appropriate Professional Development
- Address achievement gap through science connections in literacy and math

Year 2 Goals

Curriculum

- Continue writing revised, coordinated curriculum based upon final data analysis
- Design and implement interdisciplinary projects (curriculum mapping) wherever possible
- Decide on pilot or full implementation of new curriculum
- Determine the use of technology as a learning tool for both students and teachers
- Project budgetary implications of full implementation of new curriculum

Year 2 Goals (cont.)

Professional Development:

- Identify professional development needs to successfully implement new curriculum and train all faculty appropriately.

- Discuss implementation of new curriculum with task force, grade level teams, and curriculum specialists to share best practices.

Next Steps
Time

- Time to teach & learn in the classroom
  - K-5 - revisit elementary schedule
  - K-5 - integrate reading, writing and science
  - 6-8 Technology/Engineering program
  - Grade 10 - more instructional time in Biology
- Professional Development
  - K-5 - new curriculum workshops
  - 6-8 - STEM workshops, reading and writing in science
  - 9-12 -develop open-ended projects, research writing in science, content workshops

Next Steps (cont.)

Address Achievement Gap

- K-12- Investigate the connections between literacy, math and science and technology/engineering
- 6-8, 9-12 - Acquire additional staffing to assist struggling students
- Grade 10 - Pilot use of personal response system with Level 2 Biology to improve participation and knowledge
- 9-12 Research correlation between math skills and science performance

Next Steps (cont.)

Technology/Engineering

- Research, develop and pilot opportunities for technology/engineering K-12
- Develop Technology/Engineering curriculum strand K-5
- Grade 12 - Extend engineering challenge participation to more students

QUESTIONS?