Weston Public Schools
Weston, Massachusetts

K-12 Science Department
Comprehensive Program Review

Departmental Response to the Report of the Science External Review Committee

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PART I: INTRODUCTION

The Comprehensive Review Process

In the fall of 2011 the Weston Public Schools K-12 Science Department began its Comprehensive Program Review process with the implementation of a Self-Study. A committee comprised of representatives from the K-12 science department, was formed and co-chaired by Amber Bock, Assistant Superintendent, and Larry Murphy, Science Department 6-12. Due to the absence of a K-5 Science Specialist, a consultant was hired to fulfill components of the elementary assessment. The Self-Study committee was charged with completing an extensive assessment of the K-12 science programs in the Weston Public Schools. This process required that they coordinate and communicate in order to gather input from the broader department and other important stakeholders.

Throughout the following year the committee worked with the department to review current curriculum, research best practices, participate in site visits, and conduct extensive conversations regarding the strengths and needs of K-12 science in Weston. These conversations were conducted against the backdrop of several important changes impacting Science in Weston. There was the building of a new science wing at the High School, the pending release of the much anticipated NGSS (Next Generation Science Standards) document, and the state initiatives to innovate and increase education's focus on science and engineering. All of the committee's analysis and research, influenced by these other impacting trends culminated in the completion of a Self-Study report which was presented to the School Committee in June of 2012.

During the spring and summer of 2012, the Chairperson of the External Review Committee (ERC) was identified and the other members of this committee were recruited. The School Committee finalized its Charge to the Committee in September 2012. The ERC was comprised of science educators at the college, secondary, and elementary levels, administrators, and a Weston Alumnus who has pursued the field of science as a career. The External Review Committee conducted the site-visit on October 10, 11, and 12, 2012. They completed their assessment and the ERC Chair, Dr. Chris Rogers presented the final report to School Committee on January 7, 2013.

Concurrent with the External Review process, the Science department continued with work that had emerged during the Self-Study process; focusing on the development of curriculum mapping 6-12 and continuing departmental discussions of possible curriculum changes and approaches K-12. Important to this process at the elementary level was the re-hiring of Pam Bator as K-5 Science/Social Studies Specialist. Teachers who deliver Science instruction across the district received the ERC final report following its presentation to the School Committee, and began the work of developing this response. This response document has been an ongoing effort since the start of the Study process and

included use of department and team meetings, professional development time, and workshops since last year.

PART II: SUMMARY OF FINDINGS BY THE EXTERNAL REVIEW COMMITTEE AND DEPARTMENT RESPONSE

The External Review Committee commended the faculty of the Weston Public Schools for the self-reflection that guided the committee work, the talented and passionate faculty, and the pockets of innovation that were seen across the district. They challenged us to meet the call of being a truly exemplary program that can be a "thought-leader in 21st Century STEM skills." In the report they highlighted the following commendations:

Commendations:

1. A talented and enthusiastic faculty with a demonstrated interest in improving their practice of science teaching.
2. A department with a willingness to experiment and innovate at all levels.
3. A community that is supportive of the department and its goals.
4. Excellent teaching characterized by an evident rapport between teachers and students and among faculty colleagues.
5. A student population that is enthusiastic, interested, engaged, and polite.
6. Strong technology support for curricular programs.
7. An atmosphere in which teachers feel free to innovate in the classroom.
8. Quality facilities that support the program well (with the exception of the Middle-School science classrooms).
9. Use of community resources such as Land's Sake Farm and local scientist volunteer advisors in the Biology Independent Research Project.
10. A department that is aware of the challenges it faces and is actively seeking to address them.
11. Examples of authentic inquiry learning that exist within the current curriculum.
12. An existing engineering program in the Middle School that is innovative and successful.

This Response to the Review is a framework that combines all that we have learned over the last year and a half of self reflection and outside assessment. It is an effort to outline an ambitious plan to move forward with innovating aspects of instruction and creating a responsive curriculum that captures the vision of the NGSS and current practice. This document is evolving in sync with the state analysis of NGSS and our work as a district to create the program that we originally framed in our Self-Study visioning.

Important benchmarks for our future growth that were our first committee ideas:

1. Graduate more "**science thinkers**" able to ask good questions.
2. Graduate students who can understand and interpret **data** objectively.
3. Help students become active **learners**.
4. Create more links with **real world** science practitioners.
5. Incorporate more authentic **lab activities**.
6. Use authentic **assessments** of student learning.
7. Make connections with **previous grades** in order to build on what students already know.
8. Create an integrated **standard curriculum document** K-12.
9. Put our students in situations in which they may successfully **fail**.
10. Improve group working skills.
11. Use **technology** effectively.
12. Adopt meaningful **interdisciplinary** work.

We feel that this response begins to take clear planning steps to implement this starting vision of the Self-Study and hopes to achieve beyond our initial ideas of a year and a half ago. What follows is a format that organizes all we have learned from the range of documents and experiences. The format provides the guiding "Charge of the School Committee", followed by the External committee's major points of emphasis, and concluded with our response and action plan. The key areas of focus are: Instruction, Curriculum, Program Design, and Facilities & Equipment.

RESPONSE:

School Committee Charge:

I: Instruction:

To what extent does classroom instruction reflect curricular goals and best teaching practices?

- How well do teachers make use of authentic experiences, technology, and laboratory equipment in their classroom instruction?
- How effectively does the instructional model afford students opportunities for deeper study of topics and independent study in science?
- Are scientific experiences that are hands-on and inquiry based included in the curriculum?
- Are students actively engaged in critical thinking and collaborative dialogue?
- Is time provided for students to explore the materials/concept and make cross-curricular connections?
- Do we assess content and process skills?

ERC Major Points of Emphasis:

Construction of a well-articulated template for time on learning, particularly at the elementary level, balancing the time spent on disciplines by increasing science and engineering instruction time to reflect a 21st century curriculum. Students should engage in some aspect of the scientific or engineering process every day, particularly in the K-5 grades. Resources should be dedicated to help administrators to become instructional leaders for good science and engineering teaching. It is critical for teachers to understand the motivation for these changes so they can see how their efforts contribute to overall goals for students.

Commendations:

- In K-8 classrooms we observed engaging experiences involving engineering, the design process, and open inquiry.
- In 9-12 classrooms we observed aspects of authentic inquiry and data analysis.
- A strong model of inquiry-based learning exists in the Independent Research Project done by all Biology students in 10th grade.

Recommendations:

- Analyze the balance between teacher-directed and student-centered instruction.

Departmental Response:

District-wide

1. Provide and engage teachers in professional development and common planning time designed to address the following needs:
   - Develop a common understanding for the meaning of inquiry and the NGSS *Scientific Practices*.
     - Disseminate knowledge and increase comfort with these ideas.
     - Instructional models will integrate inquiry and content.
     - Formally describe what this looks like in the classroom.
     - Implement inquiry with an appropriate range of scaffolding.
   - Expand student-centered models of instruction in the classroom.
     - Move closer to "guided" and "open inquiry."
     - Create opportunities to investigate, explore, use science process skills, and engage in project based learning.
   - Provide and use planning time to integrate research-based instructional models into ongoing process of curriculum revision and alignment to NGSS standards.

2. Provide time and structure for vertical PreK-12 planning, to make purposeful decisions about both overlaps and vertical growth in content and *Scientific Practices*.

3. Expand partnerships with organizations outside the school system.
   - Use STEM-related resources of the greater community.
   - Increase real-world applications of content and process.
   - Engage authentic audiences.

4. Engage and educate families and the larger community around the vision and recommendations of the national standards, inquiry and *Scientific Practices*, and the amount of time and work that will be needed to move in that direction.

5. Continue the development of varied instructional repertoire, focusing on clear instructional models through professional development and supervision. Focus on a balance of students working versus teacher guided instruction.

K-5

Spring 2013:

- Collect and analyze data on time-on-science learning
- Professional Development for all classroom teachers
    - Bybee's 5Es (Model of Instruction)
    - Engineering Design Process
- Integration of ELA (writing) in Science
    - Claim and Evidence
    - Compare and Contrast
- Use of K-5 rubric of learning for progress monitoring

Summer 2013:

- Assess data collected on time on science learning
- Create a subcommittee of grade level representatives:
    - analyze and align units
    - create target hours per grade with clear options for teachers to achieve these hours

6-12

6. Develop plans to integrate the design process, engineering principles, and real-world applications into existing courses. Begin with pilot project with a team of teachers. Actively explore online resources and technologies that will expand online content delivery and take advantage of online networks (e.g. Open Study).

7. Increase lab based experiences with a focus on creating varied levels of entry that allow for a continuum from structured to more open-ended lab investigations. This will support an embedded differentiation of challenge and develop the goals of more open-ended learning challenges. Target would be to add at least one inquiry lab per quarter (and include at least one lab per unit).

8. Establish a committee to study and design an instructional planning tool (such as reflective questions to assess the experiment) to support self-assessing the inquiry based approaches to hands on lessons and lab based experiences K-12. Two planning assessment tools should emerge – one for K-5 and one for 6-12. Target implementation: Fall 2014.

School Committee Charge:

II: Curriculum:

Does Weston provide students with a rigorous and contemporary science education as reflected in curricular documents and related artifacts presented as part of the Program Review?

- Do course outlines and units of study reflect this goal?
- Do the Weston Science Standards reflect this goal?
- Is our assessment of student progress in attaining science learning goals effective?
- To what extent does our curriculum promote critical thinking and problem solving?
- How well does our curriculum prepare students to succeed in post-secondary science education?
- Are we using technology effectively to deliver a rigorous and contemporary science education?

ERC Major Points of Emphasis:

Curriculum observations were based on materials provided to the committee.

Commendations:

- In-house designed units are high quality and designed using materials selected from a variety of curricular resources. (K-5)
- Hands-on projects and recording of projects through the use of notebooks are incorporated into lessons. (K-5)
- Thoughtful focus questions are present to anchor lessons. (K-5)
- Open inquiry and engineering projects currently exist. (6-8)
- Students are encouraged to ask good questions and figure out answers for themselves. (6-8)
- Authentic inquiry/data analysis plays a part in courses to varying degrees. (9-12)

Recommendations:

- Identify connections to other subject areas to capitalize on integration possibilities. (K-12)
- Embed engineering into life or earth and space science. (6-12)
- Analyze and identify ways to increase time for science. (K-5)
- Increase open-ended opportunities to challenge students as critical thinkers. (K-12)

Department Response:

District-wide

1. Develop a comprehensive, coordinated K-12 science curriculum that articulates a scope and sequence, and develops a progression of content and process skills across grade levels and disciplines that reflects the emerging MA Frameworks based on both NGSS and Common Core Standards.

2. Assess and align current Weston standards to new Massachusetts' standards**.** *(NGSS final report due March 2013; Massachusetts' adoption meant to be soon after as Massachusetts has been a large part of the development of the NGSS.)*

3. The effective use of a wide range of technologies and science tools should be embedded into the ongoing curriculum planning of units and content subjects to ensure in a planful way that students are exposed to the applied uses of technologies to support and enhance science and engineering work in the classroom.

K-5

1. Review, revise, and align content of all units to the NGSS standards, cross-cutting concepts across core dimensions, Scientific Practices, and engineering design principles.

2. Along with the expansion of science instructional time that will be needed to ensure standards alignment (see *Program Design*, below), consider strategies and opportunities to expand the number of units across grade levels and placement of units within grade levels, in order to adequately develop the progression of content and process skills across PreK-5 (and 6-12).

3. Provide grade level and cross-grades planning time to share and develop consistency within classrooms at each grade level and strengthen continuity of learning vertically.

4. Embed non-fiction writing and reading opportunities throughout the curriculum, as well as writing across the curriculum and expanding the use of science notebooks to uncover misconceptions in science learning.

5. Continue to integrate the overlapping core concepts in mathematics to embed them in meaningful science content, with a special emphasis on measurement, graphing and data analysis.

Spring 2013:

- Analyze Massachusetts' response to NGSS which will be finalized in March 2013. Massachusetts will publish a draft of standards.
- Plan for summer analysis with grade levels as needed.
- Develop K-5 rubric of learning progressions focused on both process and skill development.
    - Committee work to develop rubric
    - Pilot rubric in all classrooms (assess in Fall 2013; revise as needed and implement Spring 2014)

Summer 2013 and Fall 2013:

- NGSS will be finalized in March 2013. Massachusetts will publish a draft of standards.
- Coordinate with the Health and Wellness Department (as per Wellness Program Review) to develop Health/Nutrition/Human Body unit for Grade 5.
- Provide professional development in the following:
    - How to integrate ELA and science through writing
        - Claim and Evidence
        - Compare and Contrast
    - How to effectively use science notebooks as tools of a practicing scientist
    - How to explicitly teach students to ask scientific (i.e., testable) questions
- Identify and frame current units, lessons, and other experiences using Bybee's 5Es and Design Process.
- Develop Engineering and Design Process focus in units for following grades:
    - K (embed within Balls and Ramps unit)
    - 2 (embed within Balance and Motion unit)
    - 3 (embed within Electricity and Magnetism unit)
    - 4 (develop unit)

- 5 (embed within Energy, Models, Motion, and Design--EMMD--unit and within Ecology/Ecosystems unit)
- NOTE: Grade 1 has already done this effectively with *Design and Engineering: Simple Machines at Work*

Spring 2013-Summer 2015:

- Science Specialist will provide support and professional development to teachers in instructional methodology (student centered, project-based, constructivist) and content knowledge through
  - Team-based meetings
  - Modeling and co-teaching
  - Looking at student work and progress monitoring

6-12

6. Develop a set of cohesive design & engineering principles to be implemented at the High School in the following ways:
   - Revise 9th grade Physics curriculum at all levels to embed a design & engineering module into each of the four quarters of the school year.
     - Modules will integrate Physics concepts from the quarter and then spiral forward to embed more concepts as they are covered within the course progression.
     - Modules will be developed over a two year period and layered into course planning to manage implementation impact and to provide for professional development support.
     - MCAS scores will be assessed for impact and potential implementation dips will be anticipated and discussed by the Assistant Superintendent and Department Head as needed.
   - Develop a Design and Engineering elective to be targeted for implementation in 2015-2016 as the cohort of students moving through the newly embedded engineering experiences enter Junior year.
   - Support the ongoing development of the Robotics Club with strong advisory coaching and materials support.

7. Teachers will conduct a self-analysis in teams regarding how design principles are being utilized in existing courses. A common language will be developed around the design process and then the design process will be explicitly incorporated into each course and across courses.

8. Course outlines and units of study in physics, biology, and chemistry will be further developed and refined to reflect the goal of providing students with a rigorous and

contemporary science education based on lab-based inquiry. This work should be completed by the end of summer, 2014.

School Committee Charge:

III: Program Design:

To what extent does Weston's K-12 Science curriculum provide a well-articulated, balanced scope and sequence of instruction in science?

- Does our K-12 science program reflect a coordinated and developmentally appropriate progression of learning experiences in the sciences?
- Does the curriculum reflect an effective balance of science content and science process?
- Does the curriculum achieve an appropriate instructional balance between lab-based science skills and science content needed for success on standardized state and national tests? (e.g. MCAS, SAT, AP)
- Are instructional and assessment differentiation evidenced in science classrooms?
- Are resources to students who require extra support equitably provided to science classes?
- Is adequate time and institutional support given to the study of science from K-12?

ERC Major Points of Emphasis:

Construct and implement an over-arching K-12 plan to enable all students to become scientists. Our suggestion is to set aside substantial resources (money, people, and time) to develop a coherent, research-based scope and sequence for the development of effective science practice and content knowledge by all students from Kindergarten through grade 12. In part this will require cross-school leadership; involve piloting and testing new ideas, communication between educators at all grades, and professional development for faculty and administrators alike. It will be a dynamic and continually growing document. It will also require more time for the faculty to assess and reflect on their practices and innovations.

Construct and implement an over-arching K-12 plan to enable students to become engineers. In a similar vein, we propose the construction of a well-articulated scope and sequence for the development of effective engineering practice and content knowledge for all students from Kindergarten through grade 12. It is important that the differences between science practice and engineering practice be considered and emphasized. This should begin in all of the elementary grades and be a required part of the curriculum in the Middle School and High School to meet the growing demands of STEM (science, technology, engineering, and math) knowledge of all citizens.

Commendations:

- Learning goals exist in K-5

Recommendations:

- Develop learning goals (6-12)
- Develop consistency between courses and between grades (6-12)

Departmental Response:

District-wide

1. Weston Public Schools will articulate a description of "The Scientific Mind" which is the desired product of our instruction. We will formally define the cross-cutting principles of content, process, and skill which are the essential elements of this product. We will create a set of instructional learning progressions that build these elements into the curriculum in a manner which is consistent and integrated K-12. We commit ourselves to the use of core units as the anchor instructional tools for implementing this progression within our classrooms.

2. With this framework as their support, our students will understand the habits of mind which are expressed in Science as the Scientific Method and within Engineering as the Design Process. We will provide numerous opportunities for students to explore ideas and materials, and to formalize this into scientific inquiry and engineering application.

3. Identify overarching science practices and learning progressions within the K-5 curriculum to show continuity and growth of scientific thinking.

Summer 2013

- Develop PBL course for Weston K-12 faculty.
- Utilize the faculty members who participated in the Fall 2012 PBL conference as resources for this initiative.

Fall 2013-Summer 2015

- Offer course to all faculty on PBL (online, hybrid, or face-to-face).

K-5

4. Review and adjust the elementary teaching schedule, with the goal of increasing time for science instruction. Make collective decisions to ensure consistency across classrooms within grade levels and comparable time equivalents across grade levels.

5. Consider shifting literacy connections to ELA block in order to devote more time to Scientific Practices, and making interdisciplinary connections to Social Studies.

6. Continue to embed engineering-based learning opportunities across the curriculum, in particular by exploring technology applications (e.g., Sketchup, Scratch) and programs designed to build a foundation for deeper study in later grades (e.g., Lego, Beebots).

7. Commit to core units as the anchor instructional tools that guide learning toward big ideas, key concepts and guiding questions at the center of the work. Instructional planning should be grounded in continual revisiting of standards, learning goals, and the connected learning progressions that create connections between concepts.

Spring 2013:

- Collect and analyze data on time-on-science learning.
- Integrate technology standards with science and engineering standards by piloting mechanical "builds" (LEGO WeDo) and software programming (LEGO WeDo and Scratch) during computer lab time.
    - Pilot use of Scratch and LEGO WeDo with all third grade students.
    - Pilot LEGO NXT with appropriate challenges in one third grade classroom.
    - Assess efficacy of pilot.
    - Plan long-term implementation for all third grade students.
    - Investigate growth of implementation to fourth and fifth grade students.

Summer 2013-Summer 2015:

- Identify overarching science practices and learning progressions within the K-5 curriculum to show continuity and growth of scientific thinking.
- Develop integrated Science-ELA writing and reading connections with Elementary ELA Curriculum Specialist.
- Provide professional development on "Writing in Science"
    - two-year implementation 2013-2015
    - teachers opt to take either site-based or hybrid course developed in Weston for Weston faculty
    - offered in summer and during school year

6-12

8. Establish the requirement that all students (grades 6-8) exit the Middle School having participated in at least one of three engineering electives. The grades in these electives should be incorporated into a percentage of students' overall science grade to emphasize its core importance to science & engineering content.

9. Science and Math Department Heads will analyze the alignment between math program and science program. The two departments will share a joint meeting to discuss strategies for improving shared content and alignment. (Target completion date: Winter 2013)

10. Targeting more 'open-ended, integrated content' embed clear opportunities for 6-8th students to explore topics on a deeper level within in 'content cycles'. For example, students complete a unit on Genetics and Heredity and then independently research a Genetic Disorder. Project would include finding local or global organizations that are connected to the explorations following PBL strategies.

11. Complete the development of embedded design and engineering experiences within grades 6-8. Teachers will target adding 2-3 engineering design processes. For example, the 8th grade team will be going through the entire design process with their "Bottle Rocket" experiments.

12. Assess the 6-8 curriculum revision against the NGSS document to make final adjustments to emphasized target concepts and process skills at each grade level.

13. Increase opportunities for interdisciplinary coursework, within scheduling constraints. Provide support for flexible planning and coordination to develop these opportunities.
    a Continue to explore online content delivery as a viable tool for shifting the emphasis of class time to exploration and elaboration of understanding.

14. Following the targeted PBL Course for Weston K-12 faculty, teachers will utilize professional development time to implement the ideas from this course. Project Based Learning units embedded into classes should provide context to how the content in the course is applicable or used in the real world.

    - Form teacher content or course teams to develop a project based component to embed into their course. Each science course should have at least one project based learning component (more depending on time/depth of project) appropriate to the content knowledge that the course typically covers and incorporating the design language developed by the team.

    - TIMELINE: Starting with a summer workshop with a year to collect information, from interdisciplinary or outside resource relationships, scaffold process and create timeline, and redesign content components before piloting. Time is also needed after initial pilot to assess and retool project for subsequent years.

School Committee Charge:

IV: Facilities and Equipment;

- **Do our science facilities at all levels effectively meet the demands of modern science education?**

ERC Major Points of Emphasis:

Middle School facilities: Facilities have severe limitations and need to be updated.

- Current rooms are in poor repair—electrical outlets that do not work, storage cabinets that don't close, counters that leach chemicals, sinks that do not drain.
- Rooms lack space and storage to support a project-based curriculum. One room in particular, a converted storage room, was crowded with 24 lab seats in tight formation (and the class had 25 students). Even the simple measurement lab we observed was problematic because the students had so little room to work with their meter sticks. Cabinet doors are broken and lab bench tops are unsealed and leach chemicals. Lack of a refrigerator for laboratory materials was also raised.

High School facilities: Generally very strong -- teachers highly approve of and appreciate new facilities. Lack of shop/space for engineering was mentioned. The Middle School has a shop -- perhaps an opportunity for cross-school collaboration?

Departmental Response

6-12

1. Currently the Facilities Department is working to upgrade the Middle School facilities in response to several of the core needs identified in by the ERC and identified earlier as well within the work of the Science Facilities Study Committee, completed as part of the High School Science renovation project.

2. Explore the potential development of a formulation room to support the curricular needs that emerge with the growth of design and engineering program work. Potential space use could be captured in a classroom area of "C" wing if space becomes available for non-scheduled classroom use. As program needs develop, the MS shop could be accessed as an option.

PART III: CONCLUSION

This document reflects the effort and ideas of a broad reaching segment of the K-12 Science Department. After meetings and extensive work it outlines a set of curriculum and instruction updates that define a high level science program. Work on many of these recommendations is already underway and over the next two years we anticipate achieving the majority of work outlined with selective portions to be completed in year three. Over the next several weeks we will begin a new set of meetings with principals and faculty to share this final document as our roadmap for implementation.

We would like to acknowledge and thank the members of the Science Review Committee for their dedication to the difficult work of reflection and improvement: Nan Thompson, Becky Hunnewell, Reed Konsler, Gita Foster, Mary Liu, Jody Salisbury, Jennifer Mercury, Jonathan Dietz, Erica Cole, Christine Price, and Ronit Carter. We enjoyed their effort, guidance and determination to create a student-centered, challenging learning environment for all Weston students.

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