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Curriculum Review

Final Report

June 10, 2014

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Overview

During the spring of 2013 the CPS Science Department recruited a team of teachers from across the district to join the Curriculum Review and Implementation Planning (CRIP) team. This team assembled for five full days of curriculum work between September and May with one optional afterschool session in February. Although the composition of the team has changed over the course of the year, teachers and administrators from a variety of backgrounds and experiences currently serve on the team.

The work this year focused in three key areas: overall visioning, unpacking the new MA state standards, and developing an understanding of the Understanding by Design approach to curriculum development. Throughout each meeting, work was done in each of these three areas in order to build a cohesive team with the same expectations and vision for the curriculum in the Cambridge Public Schools. Simultaneously, Lisa Scolaro and Allan Gehant compiled data to evaluate current programming.

This report was authored by Lisa Scolaro, JrK-12 Science Curriculum Coordinator and Allan Gehant, Dean of Curriculum and Programming at CRLS and is a compilation of the work done by the CRIP team during the 2013-2014 school year.

Questions can be directed to Lisa at lscolaro@cpsd.us or Allan at agehant@cpsd.us. We are thankful to the support of Dr. Jessica Huizenga, Assistant Superintendent of Curriculum and Instruction, and the whole Teaching and Learning Team.

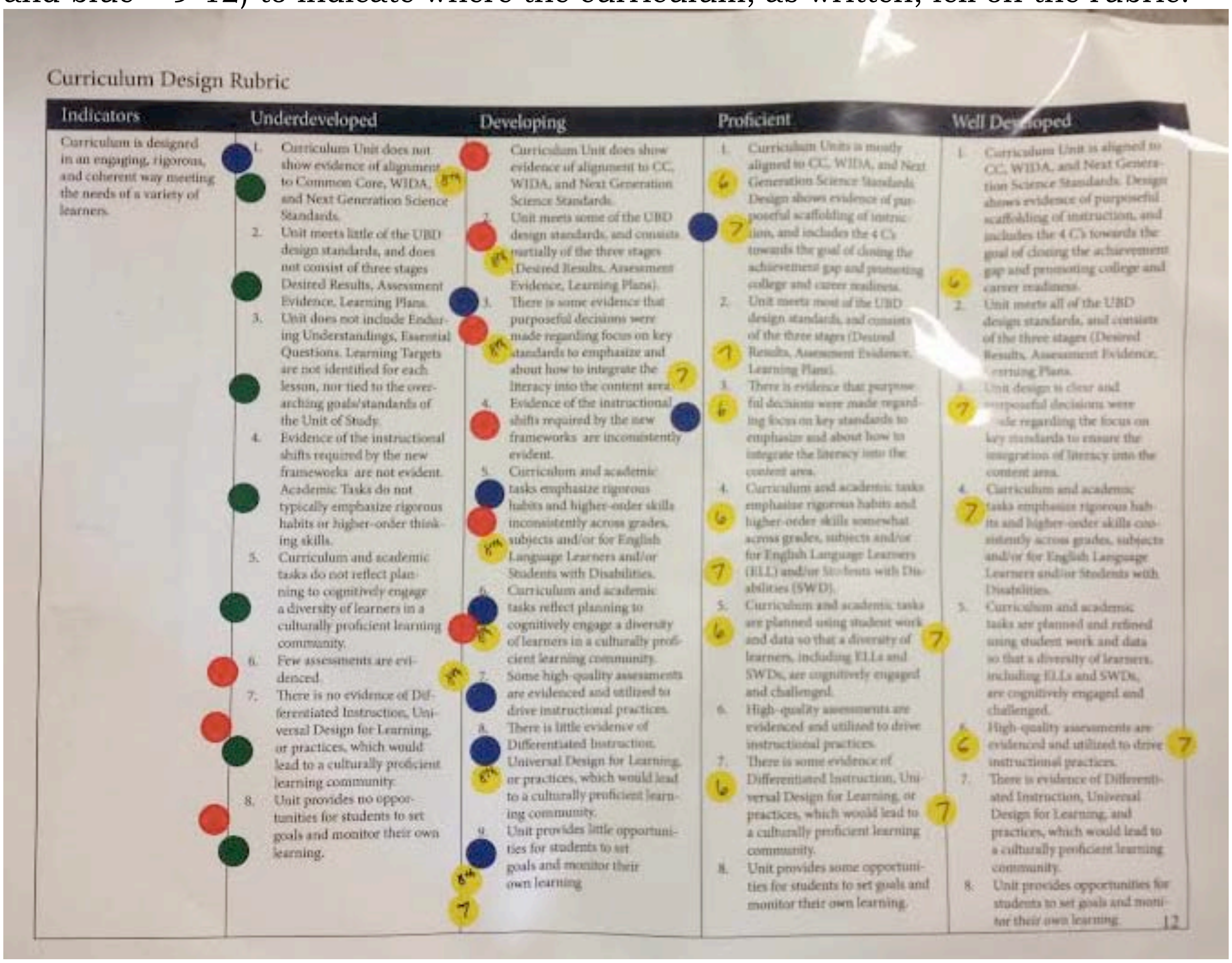
CRIP team members

Name	School	Grade Level(s)
Katie Reed	Cambridgeport	3/4
Sarah Baszto	Cambridgeport	5
Sumi Rajagopalan	Tobin Montessori School	JrK
Erin Guiterrez	Tobin Montessori School	JrK-5/Montessori Instructional Coach
Margaret Farrar	CRLS	10th Grade/Chemistry
Kris Newton	CRLS	9th Grade/Physics
Desiree Phillips	CRLS	9th Grade/Physics/Special Education
Tobe Stromberg	CRLS	11th and 12th Grade/Biology
Noel Danian	Amigos	JrK-K
Diane Griggs	Cambridgeport	1/2
Sheria Morrison	FMA	3
Michelle Frazier	Baldwin	4/5
Courteney Coyne	Amigos	3/4
David Suchy	Rindge Ave Upper School	6-8
Ingrid Gustafson	Rindge Ave Upper School and Putnam Ave Upper School	JrK-12/Educational Technology
Donna Peruzzi	Cambridge St Upper School	6-8
Paula Feynman	District	JrK-8/Academic Challenge and Enrichment
Ellen Chu	Dr. King	JrK-5/Librarian
Dan Monahan	District	JrK-8/Science Instructional Coach
Marianne Dunne	District	JrK-8/Science Instructional Coach
Susan Agger	District	JrK-12/MEC Director

<u>Visioning</u>

In order to develop a curriculum that met the expectations of the district, the CRIP team evaluated the current district curriculum against the Curriculum Review Cycle Rubric. During this initial process, inconsistencies in the rubric and misalignment were discovered. The team collaboratively revised the rubric and the new version can be found in the final Curriculum Review Cycle document.

Teachers worked in JrK-5, 6-8 and 9-12 grade band teams in evaluating the current programming against the rubric. The following is a photo of the enlarged rubric. Teacher teams placed colored dots (green = JrK-2, red = 3-5, yellow = 6-8 and blue = 9-12) to indicate where the curriculum, as written, fell on the rubric.


Curriculum Design Rubric

Indicators	Underdeveloped	Developing	Proficient	Well Developed
Curriculum is designed in an engaging, rigorous, and coherent way meeting the needs of a variety of learners.	1. Curriculum Unit does not show evidence of alignment to Common Core, WIDA, and Next Generation Science Standards. 2. Unit meets little of the UBD design standards, and does not consist of three stages Desired Results, Assessment Evidence, Learning Plans. 3. Unit does not include Enduring Understandings, Essential Questions. Learning Targets are not identified for each lesson, nor tied to the over-arching goals/standards of the Unit of Study. 4. Evidence of the instructional shifts required by the new frameworks are not evident. Academic Tasks do not typically emphasize rigorous habits or higher-order thinking skills. 5. Curriculum and academic tasks do not reflect planning to cognitively engage a diversity of learners in a culturally proficient learning community. 6. Few assessments are evidenced. 7. There is no evidence of Differentiated Instruction, Universal Design for Learning, or practices, which would lead to a culturally proficient learning community. 8. Unit provides no opportunities for students to set goals and monitor their own learning.	1. Curriculum Unit does show evidence of alignment to CC, WIDA, and Next Generation Science Standards. 2. Unit meets some of the UBD design standards, and consists partially of the three stages (Desired Results, Assessment Evidence, Learning Plans). 3. There is some evidence that purposeful decisions were made regarding focus on key standards to emphasize and about how to integrate the literacy into the content area. 4. Evidence of the instructional shifts required by the new frameworks are inconsistently evident. 5. Curriculum and academic tasks emphasize rigorous habits and higher-order skills inconsistently across grades, subjects and/or for English Language Learners and/or Students with Disabilities. 6. Curriculum and academic tasks reflect planning to cognitively engage a diversity of learners in a culturally proficient learning community. 7. Some high-quality assessments are evidenced and utilized to drive instructional practices. 8. There is little evidence of Differentiated Instruction, Universal Design for Learning, or practices, which would lead to a culturally proficient learning community. 9. Unit provides little opportunities for students to set goals and monitor their own learning.	1. Curriculum Units is mostly aligned to CC, WIDA, and Next Generation Science Standards. Design shows evidence of purposeful scaffolding of instruction, and includes the 4 C's towards the goal of closing the achievement gap and promoting college and career readiness. 2. Unit meets most of the UBD design standards, and consists of the three stages (Desired Results, Assessment Evidence, Learning Plans). 3. There is evidence that purposeful decisions were made regarding focus on key standards to emphasize and about how to integrate the literacy into the content area. 4. Curriculum and academic tasks emphasize rigorous habits and higher-order skills somewhat across grades, subjects and/or for English Language Learners (ELL) and/or Students with Disabilities (SWD). 5. Curriculum and academic tasks are planned using student work and data so that a diversity of learners, including ELLs and SWDs, are cognitively engaged and challenged. 6. High-quality assessments are evidenced and utilized to drive instructional practices. 7. There is some evidence of Differentiated Instruction, Universal Design for Learning, or practices, which would lead to a culturally proficient learning community. 8. Unit provides some opportunities for students to set goals and monitor their own learning.	1. Curriculum Unit is aligned to CC, WIDA, and Next Generation Science Standards. Design shows evidence of purposeful scaffolding of instruction, and includes the 4 C's towards the goal of closing the achievement gap and promoting college and career readiness. 2. Unit meets all of the UBD design standards, and consists of the three stages (Desired Results, Assessment Evidence, Learning Plans. 3. Unit design is clear and purposeful decisions were made regarding the focus on key standards to ensure the integration of literacy into the content area. 4. Curriculum and academic tasks emphasize rigorous habits and higher-order skills consistently across grades, subjects and/or for English Language Learners and/or Students with Disabilities. 5. Curriculum and academic tasks are planned and refined using student work and data so that a diversity of learners, including ELLs and SWDs, are cognitively engaged and challenged. 6. High-quality assessments are evidenced and utilized to drive instructional practices. 7. There is evidence of Differentiated Instruction, Universal Design for Learning, and practices, which would lead to a culturally proficient learning community. 8. Unit provides opportunities for students to set goals and monitor their own learning.

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The following general trends were observed:

Alignment to National Standards and 21st Century Skills

- New MA standards were released in January and the current program was not expected to align.
- There is no alignment to WIDA standards the curriculum. (Michelle Madera did join the CRIP team in November to introduce teachers to the WIDA standards).
- In some units of study and at some grade levels 21st century skills were explicitly outlined in the curriculum.
- Currently the T/E standards are not implemented fully at the K-8 level.

UbD Alignment

- Sixth and seventh grade units were developed using the Understanding by Design approach to curriculum development.
- Some of the high school units of study used Teaching for Understanding (a similar approach.)
- None of the elementary units were developed using UbD.

Key Standard and Literacy Integration

- Purposeful integration of literacy standards are present in some middle school units, but not consistently across the program.

Evidence of Instructional Shifts and Higher Order Thinking

- Tasks in many units of study show expectations of higher order thinking, but there is not alignment to instructional shifts expected in the new MA standards (except in some of the new middle school units.)

Diversity of Learners

- This appears to be most thought through in the new middle school units.

Assessments

- This is the most flushed out at the middle school level currently and in some

Differentiation of Instruction and Universal Design for Learners

- The teachers, rather than the curriculum, have been responsible for this.

Goal Setting and Self Monitoring by Students

- This expectation was lacking across the program.

In order to develop a cohesive district curriculum, time was devoted to building consensus around a Vision Statement (see Appendix A) for the department. This vision statement articulates what we believe a high quality science program will look like and what it takes to inspire our students. This statement will be referenced and our program will be evaluated against it throughout the process.

The term “scientifically literate” is tossed around colloquially in a variety of educational circles, but the interpretation of that phrase is inconsistent. So that the CRIP team had the same understanding of this term, they explored two scholarly articles, “Moral and Ethical Dimensions of Socioscientific Decision-Making as Integral Components of Scientific Literacy” by Troy Sadler published in the Spring 2004 issue of *Science Educator* and “The Meaning of Scientific Literacy” by Jack Holbrook and Miia Rannikmae published in the July 2009 issue of *International Journal of Environmental & Science Education.* Based on their readings, teacher groups drafted a definition. After a round of sharing and revision, a final definition was developed that is being used to guide our work. For the CPS science department:

> A scientifically literate person makes observations of and explores the world around them using all their senses. Curiosity drives this individual to research, to collect data, to test ideas, to think critically, to make connections, to apply real world understandings, and to form conclusions. The scientifically literate individual is open to monitor and adjust his/her understanding based on new evidence and as part of a continual process. He/she knows failure is a possible outcome, and questioning colleagues' findings and news reports is part of the process. Last and not least of all, the scientifically literate person is an excellent communicator of all the above as sharing his/her understandings with colleagues and the community at large is what propels scientific literacy for all.

Finally, the work of developing a district curriculum requires agreements on principles in the areas of: expectations of student work, instructional strategies, methods of assessment, and curriculum coherence. Teachers each took one domain and proposed language. After feedback was incorporated all CRIP teachers were given time to provide a second round of revisions. Based on small group and whole group discussions, UbD expectations, and best practice research on science instruction, Appendix B (Curriculum, Instruction and Assessment Expectations in Science) was developed.

The final JrK-12 Science Program will be evaluated against the Curriculum Review Cycle rubric, the CPS Science Department Vision Statement and Curriculum, Instruction and Assessment Expectations in Science.

Programmatic Data Analysis

In June of 2013 (*Fig 1: STEM Majors as Assessed by Student Survey Data in 2013*) and 2014 (*Fig 2: STEM Majors as Assessed by Student Survey Data in 2014*) graduating seniors were surveyed in order to collect data on the number students that anticipated pursuing a STEM (Science, Technology, Engineering or Math) major at the collegiate level or attending a technical college. This data was rounded out with the inclusion of Naviance data. (Naviance is the guidance software that collects student post-CRLS plans.) In 2013, 199 students returned the survey (~50% response rate) and 71 students reported a STEM major or attendance at a technical college. The response rate was lower in 2014 (~25%), but of the 108 students that returned the survey 49 declared a STEM major or planned to attend a technical college. The Naviance data indicated an additional 28 students planned to major in a STEM field or attend a technical college.

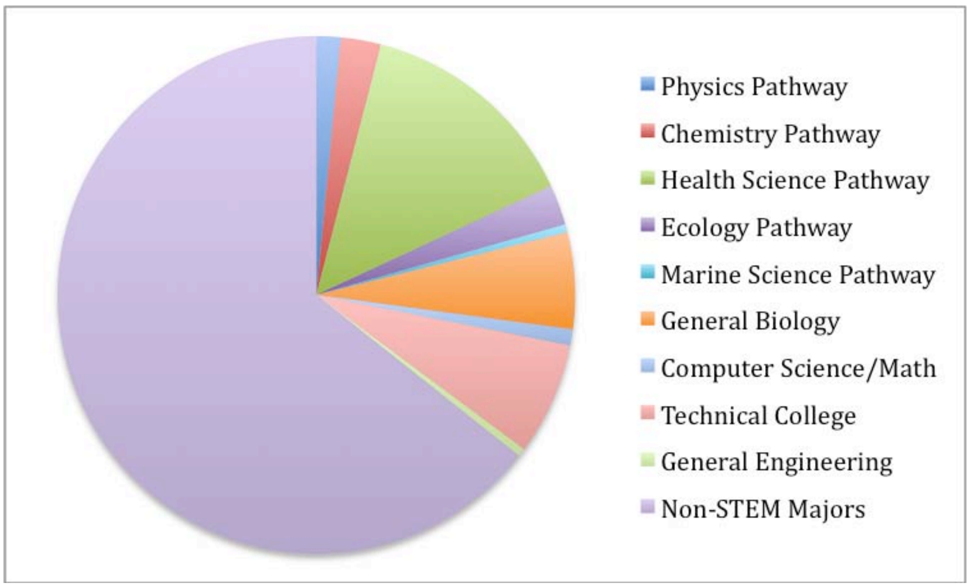


Fig 1: STEM Majors as Assessed by Student Survey Data in 2013

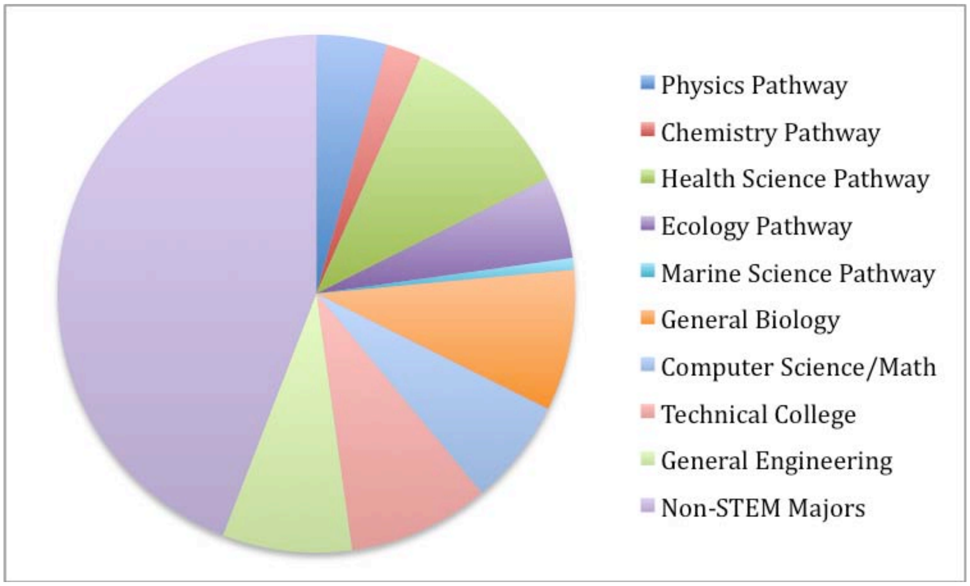


Fig 2: STEM Majors as Assessed by Student Survey Data in 2014

A February 2014 report by *US News and World Report* entitled, "Report: STEM Job Market Much Larger Than Previously Reported" reaffirmed the public perception that in demand jobs continue to be in STEM fields. Most important, of the 5.7 million STEM job openings in 2013, 4.4 million (or 77%) required at least a bachelor's degree. The study concluded that nearly half of all entry level STEM jobs required a bachelor's degree or higher while only 29% of all bachelor's degrees are earned in STEM fields. Another way of looking at the data is that for every graduate with a STEM degree there are 2.5 entry-level jobs available versus only 1.1 jobs available for graduates with a four-year degree in a non-STEM major.

Through the 6-12 Pathways meetings requested by Dr. Young during the 2012-2013 school year it became clear that students need more thoughtful progressions of courses to develop the skills to enter the in demand STE fields and successfully major in STE at the college level. Current courses have been developed based on teacher interest, rather than through development of pathways that prepare students for internships or research opportunities in the Cambridge community. The commitment has been made to develop pathways for students at CRLS that are aligned to the STE majors in demand and prepare students for opportunities to intern or do research prior to attending college. Additional analysis pointed to the lack of pathways for students that are interested in Forensic Science/Criminal Justice, Architecture or Earth Science.

As our data suggests, there is still work that needs to be done in developing students interested in and committed to pursuing STEM majors at the collegiate level. The data does seem to indicate that over the past two years the number of students that have declared, at least through Naviance and our surveys, majoring in a STEM subject, have increased dramatically.

In addition to looking at post-CRLS plans, elective science course data was dissected. An analysis of AP Science Enrollment data, disaggregated by students enrolled, tests taken and test takers went back eight years. *Figure 3: AP Enrollment Data* clearly shows that the number of enrolled students, students taking the AP test, and total AP test takers has more than doubled since the 2006-2007 school year.

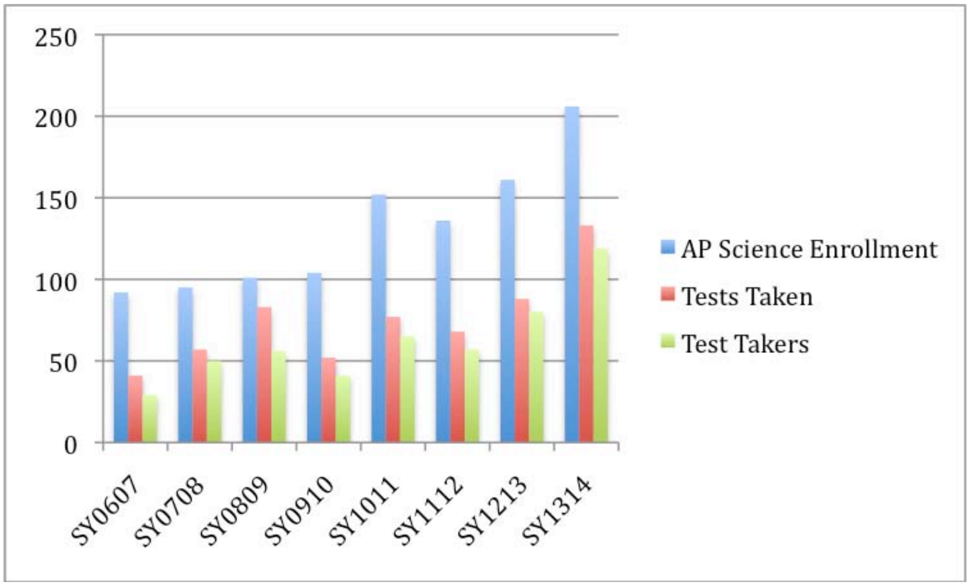


Fig 3: AP Enrollment Data

Although the studies are somewhat mixed, there is little dispute that engineering jobs are some of the fastest growing. Some reports (including a 2013 report by The Huffington Post "The Truth Hurts: The STEM Crisis is Not a Myth") point to the expectation that healthcare job openings will soar by 31%. Our data indicate that students at CRLS are taking electives in the healthcare field, but outside of our AP offerings, our pathways do not promote the skills and coursework to excite a student around engineering. Figures 4 – 6 show elective enrollments by ethnicity, gender and SES.

Figure 4 (*Elective Data Disaggregated by Gender*) clearly shows that although the overall enrollment in science electives is split fairly evenly between males and females, within particular courses the enrollment is heavily skewed male or female. Additional data needs to be collected to ascertain why students are selecting particular elective courses.

	Male	Female	SY1314 Enrollment
CRLS	51.1%	48.9%	1741
Exercise Science	77.8%	22.2%	9
Science Research & Intern	77.8%	22.2%	9
AP Physics B	73.9%	26.1%	23
AP Physics C E&M	70.6%	29.4%	17
AP Physics C Mechanics	69.4%	30.6%	36
Marine Biology	56.4%	43.6%	39
Astronomy	55.6%	44.4%	9
AP Chem	53.8%	46.2%	39
Epidemiology	50.0%	50.0%	16
AP Bio	48.1%	51.9%	52
Zoology	47.4%	52.6%	19
Organic Chemistry	38.5%	61.5%	13
AP ES	36.8%	63.2%	38
Marine Biology Internship	25.0%	75.0%	8
Anatomy & Physiology	22.0%	78.0%	41
Genetics	20.0%	80.0%	20
Oceanography	12.5%	87.5%	8

10% or more under-represented

10% or more over-represented

Fig 4: Elective Data Disaggregated by Gender

When data are broken down by ethnicity (*Fig 5: Elective Data by Ethnicity*) it is clear that only 24% of electives offer reflect the diversity of CRLS as a whole. Again, additional data should be collected in order to understand why students are selecting particular courses.

CRLS	37.50%	33.20%	11.70%	14%	3.600%	1741
	Caucasian	African American	Asian	Hispanic	Other	SY1314 Enrollment
Science Research & Intern	66.7%	0.0%	22.2%	11.1%	0.0%	9
AP Chem	53.8%	5.1%	25.6%	5.1%	10.3%	39
AP Physics C E&M	41.2%	5.9%	52.9%	0.0%	0.0%	17
AP ES	57.9%	7.9%	15.8%	7.9%	10.5%	38
AP Physics C Mechanics	52.8%	8.3%	38.9%	0.0%	0.0%	36
AP Physics B	56.5%	8.7%	30.4%	0.0%	4.3%	23
Zoology	68.4%	10.5%	0.0%	15.8%	5.3%	19
Exercise Science	55.6%	11.1%	0.0%	33.3%	0.0%	9
Astronomy	66.7%	11.1%	11.1%	0.0%	11.1%	9
Oceanography	62.5%	12.5%	12.5%	0.0%	12.5%	8
AP Bio	76.9%	12.8%	33.3%	10.3%	0.0%	52
Marine Biology	41.0%	23.1%	7.7%	20.5%	2.6%	39
Marine Biology Internship	75.0%	25.0%	0.0%	0.0%	0.0%	8
Genetics	45.0%	30.0%	5.0%	15.0%	5.0%	20
Organic Chemistry	38.5%	30.8%	15.4%	7.7%	7.7%	13
Epidemiology	37.5%	37.5%	6.3%	18.8%	0.0%	16
Anatomy & Physiology	19.5%	46.3%	9.8%	14.6%	9.8%	41

10% or more under-represented
10% or more over-represented

Fig 5: Elective Data Disaggregated by Ethnicity

Finally, when elective data are disaggregated by Free and Reduced Lunch rates (Fig 6), two of the same courses that reflect the ethnic diversity of CRLS reflect the free and reduced lunch rate of CRLS.

	Paid	Reduced	Free	SY1314 Enrollment
CRLS	55.2%	5.1%	39.7%	1741
AP ES	84.2%	5.3%	10.5%	38
Astronomy	77.8%	11.1%	11.1%	9
AP Bio	86.5%	1.9%	11.5%	52
Marine Biology Internship	87.5%	0.0%	12.5%	8
AP Chem	82.1%	5.1%	12.8%	39
Organic Chemistry	76.9%	7.7%	15.4%	13
AP Physics C Mechanics	80.6%	2.8%	16.7%	36
Epidemiology	75.0%	6.3%	18.8%	16
Zoology	78.9%	0.0%	21.1%	19
Science Research & Intern	77.8%	0.0%	22.2%	9
AP Physics C E&M	70.6%	5.9%	23.5%	17
Oceanography	75.0%	0.0%	25.0%	8
Marine Biology	64.1%	10.3%	25.6%	39
AP Physics B	73.9%	0.0%	26.1%	23
Exercise Science	55.6%	0.0%	44.4%	9
Genetics	55.0%	0.0%	45.0%	20
Anatomy & Physiology	46.3%	15.8%	46.3%	41

10% or more under-represented

10% or more over-represented

Fig 6: Elective Data Disaggregated by Free and Reduced Lunch Status

Utilizing MCAS data, Appendix C, to evaluate current programming was problematic. First, our new curriculum seeks to align to the new standards while MCAS data point to areas of strength and weakness as compared to the current standards.

Second, implementation of the district science curriculum varies across and within schools at the JrK-8 level. Therefore, it is challenging to determine how effective the CPS science curriculum would be if implemented with fidelity. Not enough classrooms implement science for the same amount of time throughout the year to tease out the curricular impact on MCAS scores. Even though the middle schools are now more cohesive, the students that took MCAS last year have yet to experience three years of a consistent and cohesive district curriculum and therefore the data is again unreliable. Finally, data that encompasses multiple grade levels, teachers, and instructional methodologies makes delineating out which factors have had the greatest impact on scores challenging. Moving forward, the new JrK-12 science program will include meaningful assessments (diagnostic, formative, and summative) that will allow for greater analysis of the effectiveness of the curriculum and its impact on student achievement.

Exploring the new (draft) MA Science, Technology and Engineering Standards

In January 2014 Massachusetts released new draft STE standards. Prior to this release, the CRIP team used the *Next Generation Science Standards* (NGSS) and *A Framework for K-12 Science Education* published by the National Research Council (NRC.) Since the new MA standards are based on these two publications, work that began prior to January was aligned to the standards.

The new MA standards are a departure from the 2006 STE Frameworks in a few key areas. First, each standard includes a science or engineering practice paired with content. In the past, standards were factoids that students needed to be able to describe. For example:

Current MA Framework		Next Generation Science Standards	
Grade / Domain	**Standard**	**Grade / Domain**	**Standard**
K-2 / Physical Science	Sort objects by observable properties such as size, shape, color, weight, and texture.	1st Grade / Physical Science	Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.* [Clarification Statement: Examples of devices could include a light source to send signals, paper cup and string "telephones," and a pattern of drum beats.] *[Assessment Boundary: Assessment does not include technological details for how communication devices work.]*

There are eight science and engineering practices that students will be assessed on:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Some of these practices overlap with the Common Core standards (See Appendix D.) Teachers explored these practices through a jig-saw structure in which teams pulled apart Appendix F from NGSS (http://www.nextgenscience.org/sites/ngss/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf). Using the K-12 rubrics, teachers developed presentations for their colleagues that outlined how the practices developed from K-12. These presentations allowed teams to become experts on two practices while producing summary documents that can be used with teachers district wide.

An expectation of the curriculum review cycle is alignment to the 4C's. The Partnership for 21st Century Skills outlines the 4C's as Creativity, Critical Thinking, Collaboration and Communication. Teachers reviewed the 4C's by reading "Preparing 21st Century Students for a Global Society: An Educator's Guide to the 'Four C's'" published by the NEA. Teachers were tasked with creating the elevator speech for their "C", defining what it looks like in the classroom, and determining which Science and Engineering practice it aligns with. This exercise allowed teachers to visualize the overlap between the 21st century skills we expect students to be proficient in and the practices Massachusetts' students will be assessed on. Their work is summarized below:

<table>
<tr><th>Elevator Speech</th><th colspan="2">What it Looks Like in the Classroom</th><th colspan="2">Where it Aligns with the NGSS Practices</th></tr>
<tr><td colspan="5">Collaboration</td></tr>
<tr><td rowspan="2">Students work effectively and respectfully with diverse teams and the expectations are that everyone participates. Exercise flexibility and show willingness to compromise to accomplish a common goal. Group shares responsibility and values individual contributions in their group work.</td><td colspan="2" rowspan="2">Established group norms, group work, and individual work with checking in with group and/or peer feedback. Groups communicating and checking in relatively frequently. Students are aware of their individual role and how it contributes to the larger group. Collaborative work happens in the classroom, across classrooms, district, region, state and larger world.</td><td colspan="2">Collaboration is not specific to any of the practices, however many of the practices would be strengthened through collaboration. Some of the practices require collaboration and others support collaboration</td></tr>
<tr><td>Supported: 1, 2, 3, 5</td><td>Needed: 4, 6, 7</td></tr>
<tr><td colspan="5">Creativity</td></tr>
<tr><td rowspan="6">Creativity requires vision and the ability to think flexibly and openly with the ability to adapt. Creative thinkers are active explorers and collaborators who view failure as an opportunity to learn and inform revisions and improvements of creative efforts.</td><td colspan="2" rowspan="6">Students are encouraged to work collaboratively to explore, solve challenging real-world problems in their classroom or community. They should be encouraged to make mistakes and understand that mistakes are a necessary part of the learning process.</td><td colspan="2">Students talking, questioning and planning together (1 and 3)</td></tr>
<tr><td colspan="2">Physical display of student created learning norms, work and models (2)</td></tr>
<tr><td colspan="2">Student directed investigation with multiple options (6)</td></tr>
<tr><td colspan="2">Peer review of process and findings (4)</td></tr>
<tr><td colspan="2">Students construct explanations and models of original ideas (6)</td></tr>
<tr><td colspan="2">Students argue their findings and respond to the findings of others (7 and 8)</td></tr>
<tr><td colspan="5">Critical Thinking</td></tr>
<tr><td>Critical thinking is “analysis, interpretation, precision and accuracy, problem solving and reasoning.” (Research by David Conley, University of Oregon on habits of mind). Critical thinkers ask significant questions, “compare evidence, evaluate competing claims and make sensible decisions.”</td><td colspan="2">It is a habit of mind, so students do it all the time without prompting. You would see students asking questions, gathering information, analyzing information, summarizing understandings, and applying understanding.</td><td colspan="2">1, 2, 3, 4, 5, 6, 7, and 8</td></tr>
</table>

<table>
<tr><th colspan="3">Communication</th></tr>
<tr><td rowspan="6">A student can articulate thoughts and ideas effectively using oral, written, and nonverbal communication for a range of purposes. Students can listen effectively and be able to understand values, attitudes, and intentions. Students can use multimedia and technology with a purposeful strategy considering audience, intentions, etc. Students can communicate effectively in diverse environments including language, culture, etc.</td><td>Students are reading, writing, speaking and listening on a regular basis.</td><td>Knowing how to ask productive questions and connect that to planning investigations (1)</td></tr>
<tr><td>Students give presentations using a variety of methods, including technology</td><td>Planning and Carrying Out an Investigation - Students need to be able to use research to build their background knowledge (reading, evaluating, interpreting). Students need to be able to communicate their procedures clearly. (3)</td></tr>
<tr><td>Students are given the opportunity to consider a variety of audiences and how communication strategies change based on audience.</td><td>Analyzing and Interpreting Data - Different conclusions can be reached so it is important to communicate and collaborate with others to make sure you are reaching valid conclusions. It is important to communicate exactly WHY the data supports that conclusion. (4)</td></tr>
<tr><td>Communication is explicitly addressed in rubrics, self-reflection, etc. as a skill that kids are working on and can continue to improve on.</td><td>Constructing explanations and designing solutions (6)</td></tr>
<tr><td>Students need to have an opportunity to communicate in different languages and learn from each other’s cultural experiences.</td><td>Engaging in argument from evidence- Students need to communicate well to share ideas and thoughts about scientific topics. They need to feel comfortable speaking in front of others. interpersonal skills would also benefit students as they engage in argument from evidence. (7)</td></tr>
<tr><td>Bring in authentic audiences to listen and present- professionals in the field, parents, students in other grades, etc..</td><td>Obtaining, evaluating, and communicating information- Students need to know how to access information, evaluate it, and also how to communicate what they learned with others. (8)</td></tr>
</table>

In addition to the inclusion of science and engineering practices, standards are no longer reported in grand bands (K-2, 3-5, etc…) but follow in the footsteps of math and ELA with grade level standards. The current MA frameworks do not include standards at the Pre-K level, but the new standards have added content at that grade level.

These differences alone mean that large-scale changes are expected, especially at the JrK-5 grade levels. Due to the Innovation Agenda, new curriculum has been phased in at the middle school level over the past two years. The NRC's Framework was used to develop this new curriculum; therefore although modifications need to be made to align to the new standards and develop a cohesive JrK-12 program, the overall scope and sequence is still valid. In order to more fully explore the impact at the elementary level a standard-by-standard comparison was done. At the high school level focus groups convened to discuss the impact of the new standards on the order of courses at CRLS.

The Standard-By-Standard Comparison at the JrK-5 level (Appendix E) shows misalignment at all grade levels. Much of the content currently addressed in our standards has shifted down and is introduced at earlier grades. For example (Fig 7), at second grade there are no standards we currently teach in the new second grade standards. Two standards have been modified and moved down to Kindergarten and one has been modified and moved down to first grade.

Grade	ESS		LS		PS		T/E	
	Old	New	Old	New	Old	New	Old	New
2	E.1.		L.4.	1	P.1.2	Part in K		K-2-ETS1-3.
		2-ESS2-1.	L.2.3	K		2-PS1-1.		
		2-ESS2-2.		2-LS2-3(MA).		2-PS1-2.		
		2-ESS2-3.		2-LS4-1.		2-PS1-3.		
		2-ESS2-4(MA).				2-PS1-4.		
						2-PS3-1(MA).		

Fig 7: Second Grade Standards Alignment

Teachers, district leaders and parents have identified the lack of Technology/Engineering as a hole in the current programming. Conversations have already begun at the district level between Cabinet, Upper Heads and the Curriculum Coordinator about the development of a Technology/Engineering class at each Upper School. Although logistical details are still being negotiated, educators have reached out to surrounding districts and schools and begun researching existing programs so that a course can launch in 2015.

More flexibility exists at the high school due to the “course” structure of the new MA standards. Instead of being grouped by grades, standards have been parceled into courses that districts can implement in any order they choose. The decision to stay with a Physics First approach or shift to another model needed to be made prior to unit development. After a careful review of the new standards, the CRLS Instructional Coaches each met with their colleagues and discussed the strengths and challenges to the current progression. Lisa met with the Instructional Coaches and collected their thoughts, concerns and suggestions into the following table:

Strengths to Current Progression	**Challenges to Current Progression**
*Heterogeneous working well for physics, but would be difficult at the 11th grade level because the math levels would have changed greatly/larger divergence in math abilities	*One thing that is added mathematically is PS2.4. Currently do this qualitatively. Most solve problems but currently this is an honors piece right now. Talk qualitatively about inverse sq. law now, not a big jump especially if CC in math causes jump
*A lot of time invested in working with freshman heterogeneously - team feels course is developmentally appropriate	*PS4.3 could be a developmental challenge for 9th grade students
*Chemistry teachers like physics happening before chemistry	*Guidance counselors placing students that did not pass Algebra I into chemistry
*Biology teachers depend on chemistry coming before biology because of the amount of biology taught	*One more year of maturity/chance to pass Algebra I would make students more successful (not unanimous feedback - they would forget Columns Law)
*Get to ESS3 right now in biology	*Real life applications used in chemistry are from biology and students do not have exposure yet so they don’t mean anything

A survey was then developed and data was collected from all CRLS teachers of science. In addition to asking all teachers about the strengths and weaknesses of the current program, teachers were questioned about possible pathways that could exist for CRLS students in order to develop an elective sequence that provided rich internship and research opportunities, as outlined earlier.

After the feedback was collected, reviewed, and evaluated, no clear rationale for switching the progression of required courses emerged. The recommendation was made that CRLS continue with Physics then Chemistry followed by Biology. All physics, chemistry and biology courses will imbed the relevant

Technology/Engineering (TE) and Earth and Space Science (ESS) standards so that students are exposed to the real life contexts and implications of the science learned. During unit development, educators are carefully including T/E and ESS standards.

Understanding by Design as an Approach to Curriculum Development

Even prior to the release of the new MA standards, teachers began to familiarize themselves with the UbD approach to curriculum development. Teachers were surveyed in order to determine their comfort level with UbD and were flexibly grouped throughout the work to ensure that they worked both in like-ability and heterogeneous groups. All three high school instructional coaches and the two district science instructional coaches participated in three days of training with Grant Wiggins in November in order to strengthen their skill set.

Teachers were first introduced to the tenets of Stage 1 by completing puzzles where they had to match statements to the appropriate category (Transfer Goal, Enduring Understanding, Goal, Essential Question, Knowledge and Skill). This formative assessment provided information on the level of comfort of the team on this first stage. Teachers were given copies of "The Understanding by Design Guide to Creating High Quality Units" Grant Wiggins and Jay McTighe and all instructional coaches were given the companion text, "The Understanding by Design Guide to Advanced Concepts in Creating and Reviewing Units."

The work completed around visioning and unpacking the new MA standards dovetailed into the work in developing the new units of study. In order to work cohesively, teachers crafted JrK-12 Essential Questions aligned to the Disciplinary Core Ideas outlined in the standards. Where appropriate, modifications at particular grade levels were proposed that addressed sophistication or vocabulary considerations. An example:

District Wide	Lower Elementary	Upper Elementary	Middle School
How does where you live matter?	How does where you live matter?	Why is balance within an ecosystem essential for its sustainability?	How have human activities impacted the balance of the ecosystem in which we live?

As unit construction has progressed, the development of Essential Questions has become iterative. The original foundation has provided a level of cohesion and the Enduring Understandings teachers have written has required revisions of the Essential Questions. This iterative process will continue as the work moves forward.

Transfer Goals frame the unit so that all teachers are clear on why the unit matters. Wiggins and McTighe suggest the 40-40-40 approach. Transfer goals should address what students should use their understandings to do independently after 40 days (the unit), 40 weeks (the school year) and 40 years. District wide transfer goals were proposed to align units to the 40-year goals. Teacher teams are developing the 40 day and 40 week goals. Forty-day goals are being developed for each unit and then when the units are completed 40-week goals will be crafted to align the units throughout the year. Current draft Transfer Goals align both with the Vision and the definition for Scientifically Literate. The current Transfer Goals are:

Students will be able to independently use their learning to:

- •Interpret, evaluate, and critique scientific claims and analyze current issues involving science or technology
- •Make personal and civic decisions that are based in sound science
- •Engage in sustained, complex and successful scientific inquiry
- •Engage in public discourse of scientific and technical issues in the news or the community
- •Make informed decisions about personal and societal use of energy

In grade span teams teachers are working on Stage 1 of unit development. Teachers have worked at grades 1, 4, 6 and 9 to parcel standards in to units and have been working together to determine the Big Ideas (Enduring Understandings) that we want students to take away from their experience with the curriculum.

Although not aligned to our new standards or the JrK-12 program, Appendix F shows an example of a 6th grade geology unit completed using the Understanding by Design approach to curriculum development. It provides an example, albeit not perfect, of the direction we are heading.

Next Steps

On June 25th and 26th teachers will work with Grant Wiggins to evaluate their drafts of Stage 1 and develop their skills in Stage 2 (assessment). Work this summer will include finalizing the content we want students to learn as well as how we will assess student mastery of this content. Each unit will include a Curriculum Embedded Performance Assessment that requires authentic application of the knowledge and skills students need to know to get to the big ideas of the unit.

Beginning in August, teachers will collaborate on the Learning Plan (Stage 3) while making sure that the lessons address best practices in science instruction. Time will be devoted to introducing teachers to Curriculum Topic Study, a resource that helps teachers explore the adult content knowledge all citizens need to have, the instructional implications regarding particular content, and the misconceptions or preconceptions students have around the topics being covered. This knowledge, coupled with the agreements we have reached around Curriculum, Instruction, and Assessment, will help teachers begin to develop a learning plan that will lead students to the knowledge and skills outlined in Stage 1.

Work will continue throughout the fall (and possibly the spring) on the units in grade 1, 4, 6 and 9 with teachers expanding out to grades 2, 5, 7 and 10. During the fall, budget requests and clear professional development plans will be presented to the district so that implementation of the first four grades can follow in 2015.

We will continue this process until all grades are rolled out following the following phase in timeline:

2015-2016	2016-2017	2017-2018
1, 4, 6, 9	2, 5, 7, 10	JrK/K, 3, 8, 11, 12

Appendix A: Science Department Vision Statement

Scientific understandings are central to our existence on Earth. We live on a planet filled with life, movement, and technology, and we have long sought to understand our world and the worlds beyond. The more complex our world becomes, and the more we seek to improve our lives, the greater our need for science literacy. Our goal is to develop scientifically literate[1] citizens by teaching them to think critically in school and as life long learners.

We set out to instill a never-ending curiosity about the world and to develop the skills necessary to investigate questions. We seek to challenge students to recognize problems, ask and explore questions, formulate working hypotheses, determine the best way to observe phenomena, construct and revise models, handle data with accuracy, reach tentative conclusions consistent with what is known, and express themselves clearly about the significance of findings. The acquisition by students of cognitive processes such as these and the habits of mind and attitudes that underlie them is a fundamental component of our standards based, nationally and state aligned science curriculum. The science department supports implementation of this curriculum through professional development focused on content and pedagogy, which insures fidelity of implementation, while providing a structured environment for continued reflection and refinement of the curriculum.

We realize that fostering these complex mental capacities in all students takes time. Students bring a range of experiences, skills and abilities to the classroom. Research indicates that students learn best by doing and then having adequate time to reflect on what they have done in order to reconcile their findings with their previous understanding of the world. Therefore our teachers organize their classrooms around frequent, hands-on explorations of natural and engineered phenomena in which students assume age-appropriate active roles as investigators and sense makers. These hands on, minds on activities set the stage for increasingly sophisticated classroom discourse that challenges students intellectually and develops their ability to communicate ideas. An integral part of our curricula are field experiences we have developed with community partnerships that offer students real world applications. Our focus on the interchange of ideas, both through discussions (science talks, peer to peer talk, etc) and written work (sketches, notebooks, exhibitions, etc), is vital to transform students into a community of scientifically literate citizens. [2]

[1] The Cambridge Public Schools defines scientifically literate based on a large body of research. We believe one needs a working familiarity with (1) the nature of science, including a grasp of the various inquiry processes scientists use to discover new knowledge as well as of the attitudes and habits of mind—honesty, skepticism, openness to new ideas, and curiosity— essential to an objective investigator; (2) the most important concepts from the body of scientific knowledge; and (3) the contexts of science, including a familiarity with the history of its development and its relationship with mathematics, technology and the economic, political, and cultural effects on society. A scientifically literate person possesses knowledge of these various aspects of science and also makes use of them in ethical decision-making and participation in civic life.

[2] See, for example, the National Research Council's *National Science Education Standards* (Washington, D.C.: National Academy Press, 1995) and the documents that preceded it, including the American Association for the Advancement of Science's *Science for All Americans* (New York: Oxford University Press, 1990), *Benchmarks for Science Literacy* (New York: Oxford University Press, 1993), and the National Science Teachers Association's *Scope, Sequence, and Coordination of Secondary School Science: The Content Core* (Washington, D.C.: National Science Teachers Association, 1993). Also see NBPTS Early Adolescence Science Standards at: (http://www.nbpts.org/for_candidates/certificate_areas1?ID=9&x=37&y=9).

Appendix B: Curriculum, Instruction and Assessment Expectations in Science

Expectations for student work:

- *Explicit expectations*: Expectations for performance are explicit in syllabi, rubrics, exemplars and assignment directions. The educator models high expectations for student performance.
- *Self-Assessment*: Students evaluate their own work to align their understanding of high quality work with the teacher's, to demystify the assessment of student work, to illuminate how they can improve their own work, and to raise their self-expectations. Over time, student self-assessment more consistently matches educator/rubric definitions of quality.
- *High expectations for all students*: Educators provide appropriate scaffolds and enrichment in order for all students to produce high quality work.

Instructional strategies:

Highly effective strategies, based in research, are selected and implemented to meet the content and cognitive complexity of the unit and the needs of students in the classroom.

- *Differentiation*: Educators are expected to differentiate content, process, and product in science classrooms at all grade levels. Among other strategies, teachers will implement flexible grouping based on student readiness, interest, and learning style.
- *Gradual release of responsibility*: Educators ensure that appropriate scaffolds are in place to support student success while intentionally removing supports as students build towards independence and progress from grade to grade.
- *Disciplinary literacy*: Educators incorporate literacy standards into the instruction and assessment in class and explicitly teach students how to become proficient readers, writers, and speakers of science.

Assessment in the classroom:

- *Common Assessments*: Common assessments (diagnostic, formative and summative) administered across the district are analyzed both individually by teachers and also with colleagues in order to inform instruction, curriculum and align expectations across the district.
- *Alignment to standards*: All classroom assessments are closely aligned to national and state science, technology, engineering (STE) and literacy standards and reflect the science and engineering practices as much as the science content.
- Appropriateness: Assessments are the appropriate complexity for the content and age of students being assessed and are administered with appropriate frequency.
- *Formative assessment*: Educators routinely pre-assess students prior to the start of a unit in order to plan the unit appropriately and make long term adjustments and use daily formative assessments to modify instruction on the spot or in the short term.
- *Curriculum Embedded Performance Assessments*: Each unit includes at least one CEPA connecting science content to relevant problems/challenges that require students to use unit-wide skills and content and are aligned to the larger transfer goals.

Curriculum coherence:

- *Curriculum spiraling*: The district science curriculum introduces content and skills at developmentally appropriate grade levels and increases the level of cognitive complexity of the knowledge and skills in subsequent years.
- *Horizontal Alignment*: There is a “tight” alignment across the district between the written and assessed curricula. Educators are “tight” on Stages 1 and 2 and clear on where flexibility exists in Stage 3.
- *Vertical Alignment*: Grade level content and skill boundaries are clearly delineated and respected so that teachers know what students should have already learned, and know what students should learn later. Educators are responsible for teaching all they are required to teach as well as respecting grade-level boundaries.
- *Curriculum revision*: Based on data, the standards-based curriculum is continuously reviewed/revised for relevance by teams of teachers who teach the curriculum. In addition, there is a long-term plan to review and revise the entire curriculum every six years.

Appendix C: District MCAS Data

All MCAS data has been pulled directly from the 2013 MCAS Report prepared by the CPS Teaching and Learning Team on September 26, 2013.

In 2013, proficiency rates increased in grades 8 and 10 from the prior year by 3% and 4% respectively and grade 5 results decreased by 1%. Science results both in Cambridge and across the state continue to be an area of needed focus.

MCAS 2013 - % Proficient/Advanced in Science

	CPS				State		
	2011	2012	2013		2011	2012	2013
Grade 5	38%	45%	44%		50%	52%	51%
Grade 8	36%	38%	41%		39%	43%	39%
Grade 10	60%	65%	69%		67%	69%	71%

Subgroup Performance

As a result of the new accountability system, the Department of Elementary and Secondary Education (DESE) began reporting MCAS Science results in the aggregate in 2012, combining together the 5th, 8th, and 10th grade results.

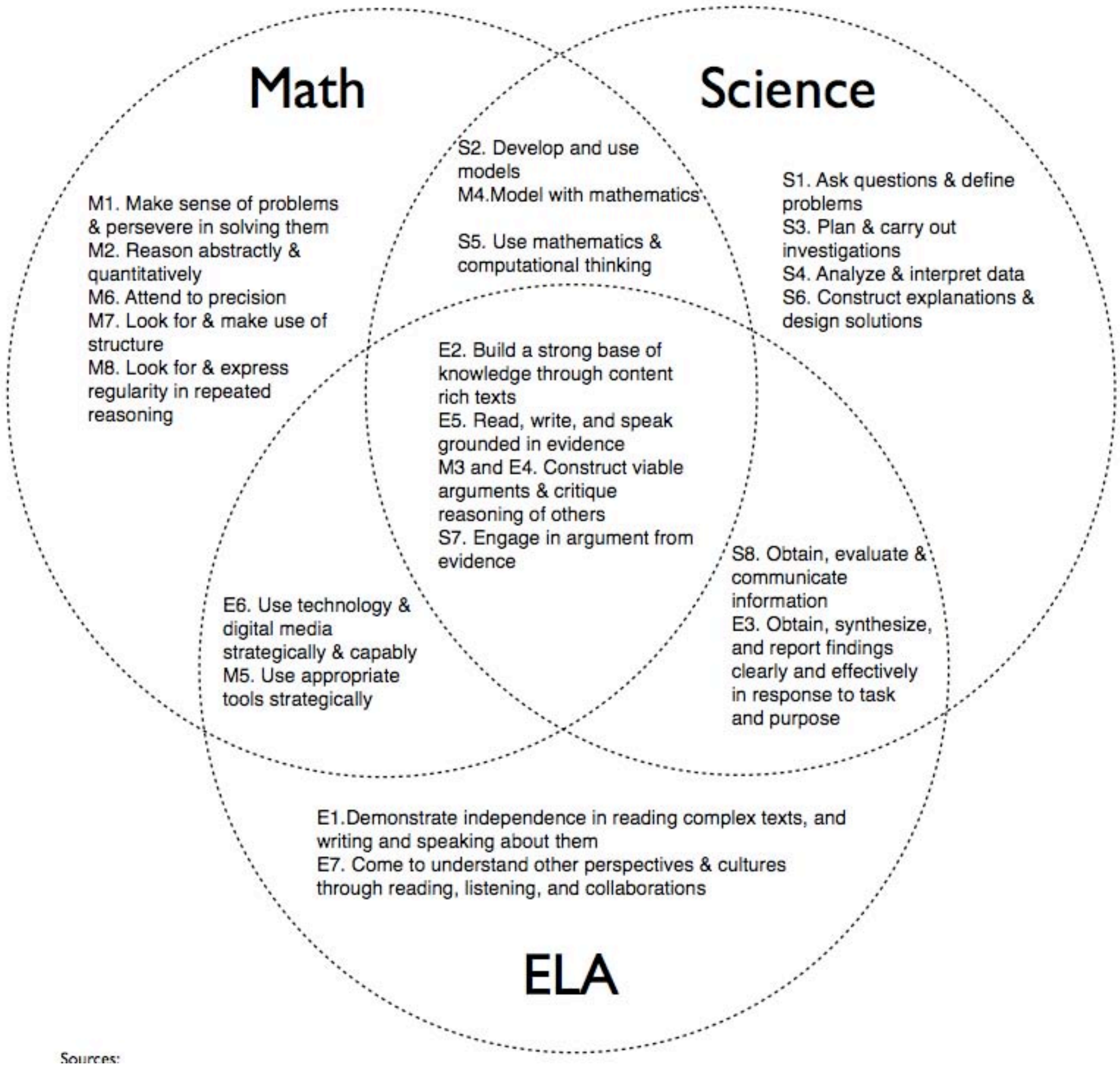
	CPS		STATE	
	2012	2013	2012	2013
All Students	49%	51%	54%	53%
Sts. w/ disabilities	17%	11%	20%	21%
ELL/FELL	12%	20%	17%	19%
Low-Income	30%	32%	30%	32%
African American/Black	25%	30%	27%	29%
Asian	66%	65%	66%	67%
Hispanic/Latino		34%	25%	27%
White	74%	68%	63%	61%
High Needs	29%	29%	30%	32%

Science

Science	Percent Proficient & Advanced				All Grades % Advanced
	Grade 5	Grade 8	Grade 10	All Grades	
Amigos School	59%	72%		64%	27%
Cambridgeport	37%				10%
Fletcher/Maynard	29%				0%
Graham and Parks	61%				34%
Haggerty	69%				31%
John M Tobin	60%				10%
Kennedy-Longfellow	17%				3%
King Open	41%				20%
Maria L. Baldwin	40%				7%
Martin Luther King	12%				6%
Morse	50%				19%
Peabody	44%				16%
CSUS		38%			11%
PAUS		46%			10%
RAUS		38%			5%
VLUS		43%			5%
CRLS			70%		33%

Appendix D: Relationships and Convergences Found in the Common Core State Standards in Mathematics (practices), Common Core State Standards in ELA/Literacy*(student portraits), and A Framework for K-12 Science Education (science & engineering practices)

From: http://nstahosted.org/pdfs/ngss/ExplanationOfVennDiagram.pdf



Appendix E: Standard-By-Standard Comparison at the JrK-5 Level

Grade	ESS		LS		PS		T/E	
	Old	New	Old	New	Old	New	Old	New
		PreK-ESS1-1(MA).		PreK-LS1-1(MA).		PreK-PS1-1(MA).		
		PreK-ESS1-2(MA).		PreK-LS1-2(MA).		PreK-PS1-2(MA).		
		PreK-ESS2-1(MA).		PreK-LS1-3(MA).		PreK-PS1-3(MA).		
		PreK-ESS2-2(MA).		PreK-LS1-4(MA).		PreK-PS1-4(MA).		
		PreK-ESS2-3(MA).		PreK-LS2-1(MA).		PreK-PS2-1(MA).		
PreK		PreK-ESS2-4(MA).		PreK-LS2-2(MA).		PreK-PS2-2(MA).		
		PreK-ESS2-5(MA).		PreK-LS2-3(MA).		PreK-PS4-1(MA).		
		PreK-ESS2-6(MA).		PreK-LS3-1(MA).		PreK-PS4-2(MA).		
		PreK-ESS3-1(MA).		PreK-LS3-2(MA).				
		PreK-ESS3-2(MA)						
		K-ESS2-1.	L.1.	K-LS1-1.	P.1.	Part in PreK Part in 2		
K		K-ESS2-2.	L.6.	PreK	P.2.	K-PS1-1(MA).		
		K-ESS3-2.	. L.3.	K-LS1-2(MA).		K-PS2-1.		
		K-ESS3-3.	L.7.	PreK		K-PS3-1.		
			L.8.	PreK		K-PS3-2.		
	E.2.		L.1.	K	P.1	Part in PreK Part in 2	T.E. 2.1	
	E.3.	1-ESS1-2.	L.2.	PreK				K-2-ETS1-1.
	E.4.	1-ESS1-1.	L.3.	K	P.4.	K		K-2-ETS1-2.
1	E.5.	K	L.7.	PreK	P.5.			
				1-LS3-1		1-PS4-1.		
				1-LS1-2.		1-PS4-3.		
				1-LS1-1.		1-PS4-4.		
	E.1.		L.4.	1	P.1.2	Part in K		K-2-ETS1-3.
		2-ESS2-1.	L.2.3	K		2-PS1-1.		
		2-ESS2-2.		2-LS2-3(MA).		2-PS1-2.		
2		2-ESS2-3.		2-LS4-1.		2-PS1-3.		
		2-ESS2-4(MA).				2-PS1-4.		
						2-PS3-1(MA).		

	E. 1		L.1			3-PS2-1.		3-5-ETS1-1.
	E.2		L.8			3-PS2-3.		3-5-ETS1-2.
	E.3		L.7	3-LS4-4.		3-PS2-4.		3-5-ETS1-4(MA).
		3-ESS2-1.	L.11					
		3-ESS3-1.	L.9					
			L. 5	3-LS3-2.				
3			L. 2					
			L.3	3-LS1-1.				
			L.6	3-LS4-2.				
				3-LS3-1				
				3-LS4-1.				
				3-LS4-3.				
				3-LS4-5(MA).				
	E.14	Grade 5		4-LS1-1.	P.6		T/E 1	
	E.15				P.7			3-5-ETS1-3.
	E.13				P.5	4-PS3-2.		3-5-ETS1-5(MA)
4		4-ESS1-1.				4-PS3-1.		
	E.12	4-ESS2-1.				4-PS3-3.		
	E.10					4-PS3-4.		
		4-ESS2-2.				4-PS4-1.		
		4-ESS3-1.				4-PS4-2.		
		4-ESS3-2.				4-PS4-3.		
	E.5		L.1		P.1			
	E.12		L.9		P.2	5-PS1-1.		
	E. 1		L. 2		P.3			
	E.2		L.3		P.4			
	E.10	5-ESS2-1	L.11	5-LS1-1.	P.5			
	E.7			5-LS2-1.	P.11			
	E.6			5-LS2-2(MA)*	P.12			
	E.9				P.6			
5	E.14	5-ESS1-2.				5-PS1-2		
	E.13					5-PS1-3		
	E.15					5-PS1-4		
		5-ESS1-1				5-PS2-1		
		5-ESS2-2				5-PS3-1		
		5-ESS3-2(MA).*						
		5-ESS3-2(MA).*						

Appendix F: Current 6th Grade Unit in UbD

Name of Unit: Geology

Grade Level: 6

Time: 10 Weeks

Stage 1 Desired Results

ESTABLISHED GOALS (G)	*Transfer (T)*
G1: Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (PS4.A.8.2) G2: The geological time scale interpreted from rock strata provides a way to organize Earth's history. Major historical events include the formation of mountain chains and ocean basins, the evolution and extinction of particular living organisms, volcanic eruptions. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (ESS1.C.8.1) G3: Plate movements are responsible for most continental and ocean floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B.8.2) G4: Some natural hazards, such as volcanic eruptions are preceded by phenomena that allow for reliable predictions. Others, such as earthquakes, occur suddenly and with no notice, and thus they are not yet predictable. However, mapping the history of earthquakes in a region and an understanding of related geological forces can help forecast the locations and likelihoods of future events. (ESS3.B.8.1) G5: Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how the Earth's plates have moved great distances, collided, and spread apart. (ESS2.B.8.3) G6: Fossils are mineral replacements, preserved remains, or traces of organisms that lived in the past. Thousands of layers of sedimentary rocks not only provide evidence of the history of Earth itself but also of changes in organisms whose fossil remains have been found in those layers. The collection of fossils and their placement in chronological order (eg, through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. Because of the conditions necessary for their preservation, not all types of organisms that existed in the past have left fossils that can be retrieved. (LS4.A.8.1) G7 Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geological processes (link to ESS2.B).	*Students will be able to independently use their learning to…* Analyze the implications of earth as a set of interconnected systems - atmosphere, hydrosphere, geosphere, and biosphere - when making personal and civic decisions.

Meaning

UNDERSTANDINGS (U)	ESSENTIAL QUESTIONS (Q)
Students will understand that… U1. A large and diverse body of evidence is necessary to construct a model of Earth and Earth's history. (G1,2,3,5,6 **K**1,2,3,4,5,6,8,9,10,11,14 **S**1,2,3,4,5 **Q**1,3,4) U2. Fossil record can be used to explain many things about Earth's past. (G2,5,6 **K**5, 6,11,12,13,14 **S**2,3,5 **Q**1,3,4) U3. Mapping of data can be used to identify patterns that can help explain past events and predict future events. (G3,4,5 **K**2,3,4,5,6,8,9,10 **S**1,2,4 **Q**1,2,3,4) U4. Earth is very old and is constantly changing. Both slow and fast changes have shaped the earth over time. (G2,3,4,5 **K**5,6,7,11,14 **S**1,2,3,5 **Q**1,3,4) U5. Earth's history includes changes on the surface of the earth and life on earth. (G2,3,4,5,6 **K**3,4,5,6,7,11,12,13,14 **S**1,2,3,5 **Q**1,3,4) U6. The uneven distribution and finite supply of resources (water, fossil fuels, minerals, metals,) is a result of the earth processes that has formed them. (G3,6,7 **K**912,13,15,16 **S**1, 2 **Q**1,2,3)	Q1. How does the earth change over time and how do we know? Q2. How does studying the past help us to predict the future? Q3. How much evidence is enough evidence?

Acquisition

Knowledge (K)	Skills (S)
Students will know that… K1. The earth's layers are the crust, mantle, inner and outer core(U1) K2. Earth's crust is broken into continental and oceanic plates (U1,3) K3. The ocean floor has geographic features (U1,3,5) K4. Earthquakes and volcanoes happen at plate boundaries (U1,3,5) K5. All plates move slowly over time and at various points continental plates have been together. The most recent one has been called Pangaea (U1,2,3,4,5,) K6. Evidence for plate movement includes fossils, volcanoes, earthquakes, shape of the continents, rock types, mountain ranges. (U1,2,3,4,5,) K7. Slow change includes mountain building and plate movement, fast change includes volcanoes and earthquakes (U4,5) K8. The magnitude of earthquakes can be measured using seismology (U1,3) K9. Patterns of seismic wave data on the surface of the earth reveals the structure of earth's interior (U1,3,6) K10. Earthquakes and volcanoes create seismic waves that travel at different speeds through different materials (U1,3) K11. Sediment is deposited over time and stores fossils in a chronological order. This is called the fossil record. (U1,2,4,5) K12. Fossils are mineral replacements, preserved remains, or traces of organisms that lived in the past (U2,5,6) K13. Not every living thing leaves a fossils due to the specific environmental conditions (burial in sediment, time) and specific properties of organisms affect fossil formation. (U2,5,6) K14. Earth's history can be divided into periods of time based on the fossil record. (U1,2,4,5) K15. The fossil record allows scientists to make inferences about the earth at particular times. (U1,2,4,5) K16. Fossil fuels are remains from living things that have been under extreme pressure underground for millions of years and there is a finite amount of them on earth (U6) K17. Differentiate between renewable and non-renewable resources in terms of the time it takes them regenerate (U6) K18. Vocabulary: Crust, mantle, core, tectonic plate, seismic wave, seismology, magnitude, plate boundary, earthquake, volcano, sediment/sedimentation, fossilization, seafloor spreading, fossil fuel, renewable resource, non-renewable resource, pangea, cambrian, precambrian, (which other time periods)	Students will be skilled at… S1. Reading maps - keys, symbol, compass, latitude and longitude S2. Using mapped geologic evidence (fossils, volcanoes, earthquakes, rocks and mineral deposits, shapes of continents and oceans, direction of plate movement) to find patterns, make inferences and draw conclusions S3. Using patterns in fossil records to create a chronological sequence. S4. Using latitude and longitude information to plot data on a map. S5. Using a geologic timeline to compare relative length of time periods S6. Creating and analyzing models S7. Engaging in scientific discourse (written and oral) using evidence to convey understandings S8. Supporting claims with clear reasons and relevant and sufficient evidence.

Stage 2 - Evidence

Evaluative Criteria	Assessment Evidence
Mapping Data • Use latitude and longitude information to plot data on a map. • Create a key to distinguish earthquake magnitude **Identify patterns of Past Geologic Events** • From data table • From the map **Use patterns to make Predictions** • Prediction of which location is safer **Use evidence in written scientific discourse to demonstrate understanding** • Statement is supported with evidence • Cites where data is from	**Curriculum Embedded Performance Assessment: The United Nations** The United Nations provides disaster relief to countries all over the world. They would like to build centers for research around seismic activity that will also be home to the teams of workers who support victims of earthquakes. While they will be studying earthquakes, it is important that the center is built in a location that will provide safety for people working for the UN. You are a geologist for a country being considered as a possible location for the center. You need to advise the UN as to the safety of the locations of their possible centers. • Indonesia (5°N 95°E) • New Zealand (45°S 170°E) • Alaska (64°N 150°W) • California (37°N 120W°) • Japan (36°N 138E°) • Chile (35°S 70°W) • Galapagos (1°S 91°W) • Puerto Rico (18°N 66W°) You will work with a group of geologists to learn about the history of one of these locations. You will each get some data about earthquakes near your location that you will analyze. You will share that data and analysis with your group members and summarize what you learned about your location. You will also create a PowerPoint or Voice Thread slide with an image of your map and a recording of your data summary. Then you will share what you learned with a geologist who studied a different site and also learn from them about their site. Next you will create a PowerPoint or Voice Thread slide comparing the geologic safety of your original location to the one of your partner. Finally your all the slides of your group will be combined and presented the United Nations representative in a full class forum where you will participate in a discussion about the safety of the various sites <u>Products</u> A. Earthquake Map • **Plot** earthquake data on coordinate map • **Create a key** to show earthquake magnitude B. PPT/Voice Thread Slides • Image of your earthquake data plotted on a coordinate map. Record statements to answer the following questions: How safe is your site? Think about **how recent, how far and how powerful.** What did you notice about the earthquakes you plotted? What did you notice about the earthquakes your teammates plotted? • Create a slide that will address your comparison with another location. Which location is safer? Think about **how recent, how far and how powerful.**
	OTHER EVIDENCE: • CEPA Part 2: Recently you advised the United Nations on where a research center should be built. When you advised them about the safety of the proposed site you only had earthquake data (magnitude, distance, and year) to use as evidence. Since your initial memo you have learned more about the way plates move and what happens at plate boundaries and therefore have more information to share with the UN. Review what you told the UN and focus on what you told them about how your site compared to another site (sheet #3) and where the research center should be built. Using your new knowledge about plate boundaries you will either enhance (add to) or refute (contradict) your original recommendation. You must include information about what happens at the nearby plate boundaries and the direction the plates are moving as evidence in your answer. • Quiz on sections 1-3 • Quick quiz on four layers of Earth • Model analysis presentation • Factors that affect fossilization scavenger hunt post-test • Section 4 and 5 test

Stage 3 – Learning Plan

Section 1: Earth's Structure and How We Know (5 Periods)

- **Experience 1: Introduction: Earth Models and What's Inside the Earth?**

Through discussion and demonstrations with models, students learn that the current theory is that the earth is layered with four layers. Demonstration of hard-boiled egg earth model, students are asked how they would go about determining what is inside the egg if they didn't already know. Class discussion then transitions to historic models of the structure of the earth – drawing a timeline to include 4 theories of the times.

1. People thought the earth was flat 1,000 years ago
2. Magellan sailed around the earth in the early 1500s leading to a revised model of earth being round.
3. Earth model was revised to contain solid rock in the 1700s.
4. A new model emerged in 1906 when seismic waves were analyzed by Richard Oldham, an Irish geologist, and were found to have different characteristics when traveling through the Earth's interior.

- **Experience 2: Readings from "Inside Earth."**

Students practice pre-reading strategies and use a JigSaw to explore readings from "Inside Earth."

- **Experience 3: Slinky Lab**

In this lab students will rotate through 4 investigative stations using a variety of Slinky assemblies to model seismic wave properties:

1. Two Slinkys stretched on a table or floor illustrating **p-wave (primary)**, one Slinky lined with foam strip illustrating wave absorption
2. Two Slinkys stretched on a table or floor illustrating **s-wave (secondary)**, one Slinky lined with foam strip illustrating wave absorption.
3. Wood block mounted Slinkys (5) illustrating **wave propagation** in all directions in the Earth from the source (not just in the direction of a single slinky)
4. Metal Slinky attached to a plastic Slinky illustrating the **reflection** of wave energy at an interface (2)

- Experience 4: Plotting Shadow Zone - Data Mapping

Continuing to build on students understanding from Slinky lab experiences, students will now plot data from simulated earthquake illustrating (using light) waves curve as they pass through the center of the earth.

Section 2: Mapping the Earth (12 Periods)

- **Experience 1: Understanding Longitude and Lattitude**

Students will learn the proper reading and use of latitude and longitude. They will use that knowledge to play online games for practice and then plot several points/identify places on Earth to show mastery.

- **Experience 2: Plotting Earthquakes and Volcanoes to Define Plate Boundaries**

Using their understanding of latitude and longitude and provided data students plot historical earthquakes to identify patterns and find the location of the earth's major crustal plates. Students plot volcano locations over their earthquake data to identify relationships between earthquake locations, magnitude and volcanic activity. Students analyze their plotted data and write reflections about the patterns, which they have identified.

- Five days built in here to complete the United Nations performance assessment

Section 3: Plate Movement (10 Periods)

- **Experience 1: Introduction to evidence/Preassessment**

Students complete a pre-assessment probe to elicit their ideas about how mountains form and about how fossils can provide information about the history of the Earth's surface. Fossil evidence will be used to set the stage for the following experience focusing on continental drift.

- **Experience 2: Using Evidence to Recreate Pangaea**

Students use geologic and geographical evidence to re-create Pangaea and better understand how landmasses have moved over the history of the Earth. Students read articles about more recent evidence to support the idea that landmasses were configured differently in the past. Students will write a letter to the editor with the intent of convincing people that plate movement is real.

- **Experience 3: Modeling Three Types of Plate Boundaries (Snack Tectonics)**

Students will experience a variety of models to understand the three types of plate boundaries. Through modeling each type of boundary, they will connect to previous experiences mapping boundaries and deepen their understanding that earthquakes, mountains and volcanoes occur along plate boundaries. Students will also view video clips that explain on-going research to track plate movement.

- **Experience 4: Evaluating Models of the Earth**

After a brief quiz, students will work in groups to evaluate a model of plate boundaries. They will then be partnered with another group to share their findings, focusing on an explanation of what the model demonstrates well and what the model does not demonstrate well. Students also reflect on the CEPA and incorporate their new understanding of plate boundaries, which directly connects to the essential question: How much evidence is enough evidence?

Section 4: What Can Fossils Tell Us? (9 Periods)

- **Experience 1: Learning From Fossils**

Students will visit the Harvard Museum of Natural History to learn about fossils and observe a variety of fossils representing different periods of the Earth's history

- **Experience 2: Timeline of the Earth**

Students start by creating a personal timeline of events. They will then create a model timeline of life on earth covering four major geologic eras.

- **Experience 3: Sedimentation and the Law of Superposition**

Students will observe how sedimentary rocks form in layers. They will learn the Law of Superposition, how it indicates fossil patterns and ages of certain rock types and practice putting layer in the correct order using a computer based game.

- **Experience 4: Factors that Affect Fossilization**

Students learn about the many different types of fossils through a powerpoint presentation. Using a web based program, students will complete a scavenger hunt to determine the factors that affect fossilization.

Section 5: Earth's Renewable Resources (5 Periods)

- **Experience 1: Fossil Fuel Formation**

Students will write and discuss their ideas about where oil comes from and how it is formed after using the probe. Utilizing short video/animations and a reading students will discuss and write about what fossil fuels are and how they are formed. The lesson ends with a simulated mining activity to model the uneven distribution of resources on Earth.

- **Experience 2: Renewable vs. Nonrenewable Resources**

There are two options for this lesson. Option 1 will begin with defining nonrenewable and renewable resources. Students will make a concept map about earth's resources and then read about natural resources and the environment identifying and classifying these resources. Option 2 has think/pair/share reading comparing renewable and non-renewable resources. Students then do an activity modeling the use of non-renewable resources.

- **Experience 3: Resource distribution of fossil fuels, minerals, metals**

Students view the brain pop video and record and categorize resources as nonrenewable or renewable and where these resources may be found on earth. The second part of the lesson is a summative test.