SCIENCE INSTRUCTION LINKED TO NHPS TEACHER EVALUATION CLASSROOM PRACTICE				
Area	#	Classroom Practice…	Potential Evidence Across Subjects	Content Specific Potential Evidence
Purposeful	1	Communicates objectives and lesson content clearly and accurately	Students know and articulate what they are learning, why it is important, and how their work will be assessed.	Learning goals are aligned to standards and always integrate science practices (skills) AND science core concepts and themes. Students are able to articulate importance of learning objectives and connections to previous and future learning in science. Beginning activities guide students to formulating scientific questions or posing problems.
	2	Employs activities aligned with student knowledge and skills, differentiating as appropriate	Student learning is evident at each point in the lesson because learning activities are appropriately sequenced based on students' needs and the learning goals.	Learning activities are sequenced over time to develop students' science conceptual understanding and skills, linking background experiences to real world phenomena: 5 E learning cycle: Engage (ask questions), Explore (conduct investigations), Explain (analyze data and information to construct understanding "sense-making"), Elaborate (Develop transferable explanations and scientific models), Evaluate (communicate/defend arguments from evidence).
	3	Offers students multiple methods to approach material and to demonstrate learning	Students access the content through listening, speaking, reading and writing.	Students interact with science concepts in hands on laboratory activities on a regular, consistent basis. Science phenomena are always encountered through a variety of modes: visual, kinesthetic, text, speaking and listening. Students are measuring, using authentic laboratory tools, making observations, writing ideas, drawing, watching, and encountering science. Students demonstrate science learning through written constructed explanations, peer discourse, presentations, visuals and multimedia, all designed to make student thinking visible. Science activities make use of mathematical analysis and practices, as well as literacy skills in textual analysis, writing, and speaking and listening.
	4	Monitors and assesses student understanding by selecting appropriate assessment strategies and adjusts as necessary	Students understand how well they are doing because they have received specific, formative feedback from the teacher.	There is evidence of probing students' preconceptions and misconceptions about science concepts and skills. Student understanding is monitored by classroom rubrics for activities, practices and skills. Students make use of self and peer monitoring. Teachers give verbal and written feedback to individuals, groups, and the whole class throughout the science lesson. Student formative and summative assessment is equally balanced between science skills and practices and science concepts and themes.

Supportive	5	Develops and maintains standards of conduct that are clear to all students and responds to student needs	Students are aware of and follow routines, procedures, systems that maximize learning time.	There is evidence of regular classroom expectations for the safe use of laboratory equipment and materials. Students make transitions between activities and areas in a safe and orderly manner. Students are equally involved and engaged in lab activities, discourse, classroom learning. There is evidence of maximum use of learning time, including material setup and cleanup. Resources, tools and relevant materials are available to support lesson implementation.
	6	Engages and includes all students in classroom activities	All students are intellectually engaged and participating in the learning process.	There is regular evidence of the authentic science practice of equal cooperative learning and investigation in designing and conducting experiments, analyzing results, and making and communicating conclusions. There is regular planned peer to peer discourse about science concepts and themes where students listen to each other's ideas in order to construct understanding. Classroom activities in science engage all in discussion, experimentation, writing, using lab equipment, and other practices. Teacher questions are largely open ended and require all students to formulate essential understandings.
	7	Provides opportunities for meaningful student choice	Students have meaningful choices based on standards for the grade and content.	Students have opportunities to formulate their own questions or problems, to design their own investigations, and to select multiple methods of learning. Students have opportunities to make connections to their own interests and world, as well as develop their own ways of demonstrating learning

Meaningful	8	Promotes in-depth knowledge, understanding of significant concepts, and higher order thinking skills	Students are intellectually engaged and challenged appropriately to build knowledge and skills based on the Common Core Instructional shifts.	Student understanding is developed through a guided inquiry model: In order to develop students constructing their own explanations through sense making, they are mostly allowed to engage and explore with science phenomena and concepts before direct instruction, introduction of academic terms, or formal clarifications. After students have developed their own explanations, strategies around learning academic vocabulary (Frayer model, nonlinguistic representations, reading in context) are used to further develop common understandings. Provides opportunities for students to apply and transfer knowledge to new questions and problems.
	9	Engages students in substantive conversations with purposeful questions to promote inquiry and learning	Students are engaged in meaningful academic discourse with peers and the teacher. Students received guidance and feedback about how to speak with one another.	Students have planned and regular peer to peer discourse about science concepts and skills, and their discourse has clear academic purpose and structure. Teachers and students use “talk moves” to guide student discussions: such as wait time, rephrasing, “say more”, “why do you think that”, “what do you think”. Students share, expand, and clarify their reasoning while making their thinking visible, digging deep into their reasoning and arguments with evidence and use academic language. Students listen carefully to each other and think with others.
	10	Makes connections to increase relevancy for students, including to different lessons, to different content areas, and to each student’s world outside of the classroom	Students’ understanding and learning are enhanced by intentional links to the real world and students’ interests.	The science question or problem in the lesson has clear and explicit connections to the real world, such as the link to a societal problem, the application to students’ life or interest, the use of science and technology to solve an issue, or the transfer to new observed phenomena. Students are able to explain why they are learning the science concepts and skills and why it is important to their life, local or greater community. (Either currently or in a historical context). There is evidence of connection to other disciplines (arts, health, language, social studies) beyond the use of literacy and math practices. There is some evidence of connection of science concepts and practices to possible STEM careers.

** Students goal FIGURE IT OUT NOT **LEARN ABOUT!!!**

***** LEARNING CYCLE** model. One such model, the "5-E Model", engages students in experiences that allow them to observe, question and make tentative explanations before formal instruction and terminology is introduced. The sequence of learning activities is one of the key research proven ways to help students learn science concepts and skills. Generally, there are five stages in an inquiry-learning unit:

Engagement: stimulate students' interest, curiosity, and preconceptions.
Exploration: first-hand experiences with concepts without direct instruction;
Explanation: students' explanations followed by introduction of formal terms and clarifications;
Elaboration: applying knowledge to solve a problem. Students frequently develop and complete their own well-designed investigations.
Evaluation: students and teachers reflect on change in conceptual understanding and identify ideas still "under development".

-**FOCUS ON SCIENCE PRACTICES, NOT Content** . Students are trying to make sense of the world and phenomena through the practices of questioning, modeling, investigating, analyzing, solving, explaining, arguing and communicating

-**Create a Climate for Learning**: well planned lessons, positive teacher attitude, safe, secure, enriching environment.

-**Setting Objectives/Providing Feedback**: Objectives are always clear for all class activities, students always know how they are meeting objectives through metacognition or teacher/peer feedback. Objectives include science concepts as well as skills, lab practices, 21st Century Skills and higher order thinking skills.

-**Use Warm Up Activities, Questions, Cues, Advance Organizers**: Starter questions generate interest, cue students as to learning activities, and provide a reference throughout a lesson

-**Assess Prior Knowledge/Misconceptions**: Students have to construct their internal model of science concepts and reconcile it with previous experience, often leading to hard to overcome misconceptions.

-**Follow a Guided Inquiry** Learning Cycle Model/Open Ended Inquiry: Guided Inquiry into a teacher posed question by students leads to students investigating their own questions, generating and testing their own hypotheses, analyzing data, and drawing conclusions.

-Experiential, Manipulation and Hands on Learning: Students are given the opportunity to experience science rather than listen or read about it and touch/feel.

-**Lab and Science Skills:** Class Activities are designed to teach students science lab skills, and provide experience with authentic lab tools, experimentation, and data analysis.

-**Generating and Testing Hypotheses**: students given the opportunity to investigate their ideas.

-**Analyzing Data** Students use appropriate mathematical techniques to collect numerical data using measurement skills, analyze and evaluate their data, as well as to find patterns and visually represent their findings.

-**Peer Discourse: Self-Explanation/Discussion**: Students given the opportunity to explain and discuss ideas are better able to connect prior and new knowledge and experiences. The whole class is designed around making their thinking visible. Teachers use talk moves and guide this collaborative discourse.

Key Instructional Strategies New Haven Science **(in curriculum 2007, revised 2010, 2015, 2017)**

-**Opportunities to Communicate/Cooperative Learning**: Science is a group endeavor, as is ilearning. Students learn best by communicating /learning from each other.
-**Vary the Way Students Learn**: Lab groups, learning centers, projects, and other alternatives to traditional lecture allow for individualized instruction. Differentiation is in the lesson instruction, not just in the assessment or assignment.

-**Vary the Structure of Lessons**, Use Research Based Strategies: Lesson structure depends on the concepts and skills being learned and assessed. Brain based research in learning points to specific effective varying structures.

-**Practice Effective Questioning Techniques**: Questions are the tool to move towards a student-centered classroom, and different types of questions help guide instruction and learning.

-**Provide models, scaffolds and structures** Students are able to complete learning tasks by using structures and are asked to complete steps following a teachers' model before being asked to work individually

-Sense Making and Argumentation: Students engage in talk and argument around science concepts, make connections between new learning and previous learning and big ideas, apply learned concepts to new situations, reflect on their thinking and changes in their thinking (metacognition), engage in scientific discourse and critique, make claims and defend the claims with evidence and continually review and revise their ideas to deepen their understanding. Teachers structure time, activities, and learning opportunities to support this sense making.

-**Identify Similarities and Differences/Graphic Organizers**: Science concepts are often organized into structures by humans attempting to understand nature. Help students understand the classification and organization of knowledge by continually comparing, classifying, as well as describing analogies and relationships.

-**Scaffolded Writing Practice**: Students can move from oral explanation to written explanation through careful guidance/practice, including both expository and persuasive writing in science.

-**Relevance:** There is a connection to students' lives and experiences. There is a connection to their world and to their future, including science /STEM careers.

-Strengthen Comprehension for Content Area Reading Text: provide guided focus question, organizers, response and discussion questions, summarize, evaluative prompts based on reading.

-**Use of Academic Language** Students are able to use academic language, not simply memorize vocabulary, by constructing the meaning behind scientific words by regular experience with their use, including comparisons, graphic organizers, and talk alouds, and use words after they have experienced the science.

-**Non-Linguistic Representations**: Models, drawings, and pictures all can help understand science.

-**Allow Opportunities for Peer Review**: Students are frequently asked to evaluate others' work on standardized testing and must be given regular opportunities as part of their science experience.

-**Create and Embed Science, Technology and Society** (STS), issues, and other items relevant to students' lives. These interdisciplinary learning activities are designed to engage students in the applications of science using their critical thinking skills and content knowledge. They afford students the opportunity to examine ideas and data related to historical, technological, and/or social aspects of science concepts and content. Teachers also actively promote STEM careers.

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The tables were adapted, with permission, from the book Science Teaching and the Development of Thinking, by Anton E. Lawson, Wadsworth Publishing Company, 1995.)

Teacher's Role and Actions in the 5E Teaching Model

""5E""s	Consistent with Model	Inconsistent with Model
Engage	• Creates curiosity • Raises questions • Elicits responses that uncover what the students know or think about the concepts	• Explains concepts prematurely • Provides definitions and answers • States conclusions
Explore	• Encourages students to work together without direct instruction • Observes and listens to students' interactions • Asks probing questions to redirect students' investigations when necessary • Acts as consultant for students	• Provides answers and closure • Lectures as a main delivery • Informs students about mistakes • Leads students step by step to a solution • Acts as the sole source of information
Explain	• Encourages students to explain concepts and definitions in their own words • Asks for justification (evidence) and clarification from students • Formally provides definitions, explanations, and new labels • Uses students' previous experiences as basis for explaining concepts	• Neglects to solicit students' explanations • Accepts explanations that have no justification • Introduces unrelated concepts or skills. • "Plays around" with no goal in mind
Elaborate	• Expects students to use formal labels, definitions, and explanations provided previously • Encourages students to apply or extend concepts and skills in new situations • Refers students to existing data and evidence and asks questions such as "What do you already know? Why do you think so?"	• Provides definitive answers • Tells students that they are wrong • Lectures • Leads students step by step to a solution • Explains how to work through problems
Evaluate	• Observes students as they apply new concepts and skills • Assesses students' knowledge and skills • Provides students with formative feedback to enhance their thinking or behaviors • Allows students to assess their own learning and group-process skills • Asks open-ended questions such as "What do you know about x? How would you explain x? Based on what evidence?"	• Tests vocabulary words, terms, and isolated facts • Introduces new ideas or concepts • Creates ambiguity • Promotes open-ended discussion unrelated to concepts or skills • Provides only summative feedback

Students' Role and Actions in the 5E Learning Model

"“5E”"s	Consistent with Model	Inconsistent with Model
Engage	• Asks questions such as" why did this happen? What do I already know about this? What can I find out about this?" • Shows interest in the topic	Asks for the "right" answer Offers the "right" answer Insists on answers or explanations Seeks one solution
Explore	• Thinks freely but within limits of the activity • Tests predictions and hypotheses • Forms new predictions and hypotheses • Tries alternatives and discusses them with others • Records observations and ideas • Suspends judgment	Passive involvement Works quietly with little or no interaction with others "Plays around" indiscriminately with no goal in mind Stops with one solution
Explain	• Explains possible solutions or answers to others • Listens critically to others' explanations • Questions others' explanations • Listens to and tries to comprehend explanations offered by teacher • Refers to previous activities • Uses recorded observations in explanations	• Proposes explanations from "thin air", with no relationship to previous experiences • Brings up irrelevant experiences and examples • Accepts explanations without justification • Does not attend to other plausible explanations
Elaborate	• Applies new labels, definitions, explanations and skills in a new but similar situation • Uses previous information to ask questions, propose solutions, make decisions and design experiments • Draws reasonable conclusions from evidence • Records observations and explanations • Checks for understanding among peers	"Plays around" with no goal in mind Ignores previous information or evidence Draws conclusions from "thin air" In discussion, uses only labels provided by teacher
Evaluate	• Answers open-ended questions by using observations, evidence, and previously accepted explanations • Demonstrates understanding or knowledge of concept or skill • Evaluates his or her own progress and knowledge • Asks related questions that would encourage future investigations	Draws conclusions without using evidence or previously accepted explanation Offers only "yes" or "no" answers and memorized definitions or explanations as answers Fails to express satisfactory explanations in his or her own words Introduces new, irrelevant topics

Table 1. Summary of the BSCS 5E Instructional Model

Phase	Summary
Engagement	The teacher or a curriculum task accesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities.
Exploration	Exploration experiences provide students with a common base of activities within which current concepts (i.e., misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation.
Explanation	The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. This phase also provides opportunities for teachers to directly introduce a concept, process, or skill. Learners explain their understanding of the concept. An explanation from the teacher or the curriculum may guide them toward a deeper understanding, which is a critical part of this phase.
Elaboration	Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities.
Evaluation	The evaluation phase encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives.

SCIENCE IS FOR ALL STUDENTS

All students, regardless of age, sex, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science, should have the opportunity to attain high levels of scientific literacy. Excellence in science education embodies the ideal that all students can achieve understanding of science if they are given the opportunity. Our goal is to ensure that all students at all levels achieve science literacy, for science is the key to their future.

SCIENCE LITERACY

Science literacy is a combination of understanding major science concepts and theories, using scientific reasoning, and recognizing the complex interactions between science, technology and society. Scientific literacy requires the ability to apply critical thinking skills when dealing with science-related issues. A scientifically literate person is able to transfer knowledge of the academic theories and principles of science to practical applications in the real world. Scientific literacy also implies having the capacity to pose and evaluate arguments based on evidence and to apply logical conclusions from such arguments. Scientific literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed.

LEARNING SCIENCE IS AN ACTIVE PROCESS

Learning science is something students do, not something that is done to them. In learning science, students describe objects and events, ask questions, acquire knowledge, construct explanations of natural phenomena, test those explanations in many different ways, and communicate their ideas to others. This term "active process" implies physical and mental activity. Hands-on activities are not enough—students also must have "minds-on" experiences. Science teaching must involve students in inquiry-oriented investigations in which they interact with their teachers and peers. Students establish connections between their current knowledge of science and the scientific knowledge found in many sources; they apply science content to new questions; they engage in problem solving, planning, decision making, and group discussions; and they experience assessments that are consistent with an active approach to learning. Emphasizing active science learning means shifting emphasis away from teachers presenting information and "covering" science topics. The perceived need to include all the topics, vocabulary, and information in textbooks is in direct conflict with the central goal of having students learn scientific knowledge with understanding. Inquiry into authentic questions generated from student experiences is the central strategy for teaching science.

TEACHERS OF SCIENCE GUIDE AND FACILITATE LEARNING In doing this, teachers:

-Display and demand respect for the diverse ideas, skills, and experiences of all students.
-Focus and support inquiries while interacting with students.
-Encourage, model, and emphasize the skills, attitudes, and values of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterize science.
-Orchestrate discourse and ongoing discussion among students about scientific ideas.
-Challenge students to accept and share responsibility for their own learning and the learning of all members of the community.
-Recognize and respond to student diversity and encourage all students to participate fully in science learning
-Enable students to have a significant voice in decisions about the content and context of their work.
-Nurture collaboration among students.

SCIENCE INSTRUCTION

Science uses instructional strategies and resources to promote thinking about the content, and students are encouraged to critically discuss ideas, seek information, and validate explanations. Students are trying to make sense of the world and phenomena through the practices of questioning, modeling, investigating, analyzing, solving, explaining, arguing and communicating. They are trying to FIGURE IT OUT not LEARN ABOUT.

Concepts: The overall instructional strategy for teaching science skills and concepts is that of learning by doing. Abstract concepts in science are explained in class using diagrams, models, simulations, and a variety of media. Students take notes in class, and participate in class discussions. There are questions asked of the students daily, both written and oral, that ask them to explain concepts and relate scientific behavior to real life phenomena. The teacher models the use of quantitative and qualitative analysis through some problem solving strategies in class, which the students then practice, both in groups and individually.

Labs/Activities: In each unit of study, students participate in laboratory investigations at least once a week. The lab investigations are sometimes set procedures in which the students practice the skills of observation, measurement, and data analysis. Many other lab experiences ask the students to design their own safe experiment: formulating hypothesis, controlling variables, and communicating and explaining their results and conclusions. The lab experiences directly relate to the concepts as well as show real life applications of science concepts. Students explore phenomena and collect empirical evidence to support their own explanations.

Real Life: Students apply the knowledge they have learned by using science concepts to make decisions about current issues in each unit. They write persuasive essays, conduct collaborative and independent research, and participate in forums and debates. The students are expected to synthesize information from various resources and construct carefully reasoned opinions about the issue. There are case studies and simulations that require students to learn and apply their science knowledge and make judgments.

The emphasis in all the instructional activities is to promote higher order thinking skills and making connections. Students learn how to use resources, rather than memorizing many facts, and apply their laboratory experiences to other situations.

A useful structure for inquiry-based learning units follows a **LEARNING CYCLE** model. One such model, the "5-E Model", engages students in experiences that allow them to observe, question and make tentative explanations before formal instruction and terminology is introduced. Generally, there are five stages in an inquiry-learning unit:

Engagement: stimulate students' interest, curiosity, and preconceptions.
Exploration: first-hand experiences with concepts without direct instruction;
Explanation: students' explanations followed by introduction of formal terms and clarifications;
Elaboration: applying knowledge to solve a problem. Students frequently develop and complete their own well-designed investigations.
Evaluation: students and teachers reflect on change in conceptual understanding and identify ideas still "under development".

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ASSESSMENT:

<u>Assessment Strategies:</u>

Students are assessed with a variety of methods on their knowledge of science concepts and skills and how they apply to the real world.

Diagnostic assessment can be used to determine the learning needs of students.
Formative assessment can be used during instruction in order to guide students and increase learning. Summative assessments are used to identify achievement of goals and objectives.

Daily classwork and homework is used to check for understanding of main ideas and application of the techniques and skills of science. These daily assessment tools include a mixture of written explanations, diagrams, model building, and problem solving. Students are assessed on their laboratory skills using rubrics and class monitoring. Students are assessed on their ability to explain unit-related concepts and their conclusions on experimentation results by written lab reports, written explanations on quizzes and tests, as well as occasional oral explanation of laboratory ideas and procedures.

There are periodic unit quizzes and tests, which assess students' skills and knowledge in a similar manner to their daily instructional activities. The written quizzes and tests include a mixture of knowledge and comprehension questions, as well as questions which require students to demonstrate knowledge of inquiry skills, explanation of concepts, as well as making connections to other concepts and everyday experiences. The assessment tools include questions about cause and effect, steps of scientific processes, and explanation of phenomena, and are not focused on just vocabulary and word problem solving. Tests and quizzes, as well as midterm and final exams, may include a lab performance component.

Students are assessed on their ability to explain science ideas, do research, and defend decisions about scientific issues by the use of projects and class simulations. Projects require some level of judgment and thinking by the students and extend beyond research into analysis and synthesis. Group and interpersonal skills are included. Rubrics detailing students' ability to present, discuss, and use scientific research, both lab results and issues, are used by students, peers, and the teacher.