# An Effective Standards-Based K-12 Science and Technology/Engineering Classroom

The MADOE's Science and Technology/Engineering team and the Science Liaison Network have developed a shared vision of standards-based science and technology/engineering (STE) learning and teaching. Based on this vision, we have articulated characteristics of an effective standards-based science and technology/engineering classroom, applicable to grades K-12. Additional indicators illustrate and exemplify these characteristics.

This document represents the present state of this work and is meant to be adjusted over time. The purpose of this document is to support activities that advance standards-based educational practice and enhance classroom instruction. Such activities may include: formal study, dialogue and discussion, classroom observations, one-on-one professional development, coaching support, mentor-mentee collaborations, and other professional growth opportunities.

## ***A Shared Vision of Science and Technology/Engineering Learning and Teaching***

Students learn when they are personally invested and engaged, and there is arguably no more engaging subject than science/technology/engineering! Students actively participate in learning when they understand the relevance of a lesson, regularly communicate their thinking, reflect on their experience, and apply content knowledge, inquiry skills and engineering design to the world around them. Facilitating learning requires knowledgeable teachers who use a variety of instructional methods and standards-based assessments to differentiate instruction. Teachers continually encourage students to reach their full potential, and have—and appropriately use—time and resources to maximize opportunities for student intellectual growth and inquiry. We believe all students can meet or exceed Massachusetts' standards in science and technology/engineering to develop critical understandings necessary for participatory citizenship in our scientific and technological society.

# Characteristics

## I. Student Engagement

*Students learn science and technology/engineering when…*

1.1. they value and find meaning in each learning experience.
1.2. they examine, reflect, and communicate their thinking and understandings of the concepts in each lesson.

## II. Instructional Design and Delivery

*Students learn science and technology/engineering when…*

2.1. learning objectives and lessons are standards-based.
2.2. concepts are accurate and vocabulary is precise.
2.3. thoughtfully integrated laboratory and investigative experiences enhance student development of content knowledge, inquiry skills, and the design process.
2.4. lessons elicit student experience, prior knowledge, and misconceptions while addressing readiness and learning styles.
2.5. differentiated learning experiences support the range of learners in the classroom.
2.6. formative assessments and student responses to probing questions inform instructional decisions.

## III. Student Expectations

*Students learn science and technology/engineering when…*

3.1. the learning objective(s) of each lesson are evident and clear to all students.
3.2. all students are expected to participate and demonstrate their learning of the learning objective(s).

## IV. An Environment for Learning

*Students learn science and technology/engineering when…*

4.1. the classroom atmosphere is orderly, respectful, and focused on student learning.
4.2. students are physically safe.

## V. Documentation and Communication of Student Learning

*Students learn science and technology/engineering when…*

5.1. classroom assessment systems document the progress of student learning toward each standard.
5.2. multiple types of diagnostic and summative assessments are regularly used to gauge student understanding and provide feedback to students.

# I. Student Engagement

| 1.1 Students learn science and technology/engineering when they value and find meaning in each learning experience. | |
|---|---|
| The students:<br>• Can explain the purpose and rationale for the lesson.<br>• Have an opportunity to choose how they learn (not what they learn).<br>• Tackle real-world problems and applications.<br>• Make connections between the lesson and personal experience.<br>• Relate their personal and academic interests to their learning of STE.<br>• Indicate engagement through questions, responses, and attentiveness. | The teacher:<br>• States the objectives of the lesson and provides students with a rationale for learning.<br>• Connects new learning with students' prior knowledge and experiences.<br>• Paces the lesson to ensure that all students are actively engaged.<br>• Responds to student feedback and makes adjustments to promote active student participation. |
| 1.2 Students learn science and technology/engineering when they examine, reflect, and communicate their thinking and understandings of the concepts in each lesson. | |
| The students:<br>• Discuss and debate their STE understandings.<br>• Articulate their understanding using appropriate STE language.<br>• Support their reasoning with data and evidence.<br>• Ask questions and make comments that indicate their understanding of and reflection on STE concepts.<br>• Monitor their own understanding and self-advocate when they need assistance.<br>• Identify and correct their misconceptions through exploration and discussion.<br>• Respectfully correct one another's thinking or explanations.<br>• Make interdisciplinary connections. | The teacher:<br>• Models thinking using appropriate STE concepts, skills, and vocabulary.<br>• Explicitly teaches thinking and reasoning skills and strategies.<br>• Asks students to explain their thinking and provide evidence to support their claims.<br>• Provides students with adequate time for sense-making and meaningful closure.<br>• Provides opportunities for students to identify and challenge their own pre-conceptions.<br>• Clearly addresses common misconceptions. |

# II. Instructional Design and Delivery

<table>
<tr><td colspan="2">2.1 Students learn science and technology/engineering when learning objectives and lessons are standards-based.</td></tr>
<tr><td>The students:<ul><li>Know the standards-based learning objective(s) of the lessons.</li></ul></td><td>The teacher:<ul><li>Creates learning objectives based on State STE standards and district curriculum.</li><li>Ensures that all components of the lesson (learning activities, homework, assessment, etc.) contribute to the lesson objectives and to student mastery of the standard(s).</li></ul></td></tr>
<tr><td colspan="2">2.2 Students learn science and technology/engineering when concepts are accurate and vocabulary is precise.</td></tr>
<tr><td>The students:<ul><li>Can accurately explain the central concepts learned using appropriate vocabulary.</li></ul></td><td>The teacher:<ul><li>Demonstrates accurate content and models the use of appropriate, precise vocabulary.</li><li>Can explain STE concepts and ideas in multiple ways to scaffold student understanding.</li><li>Presents STE as a dynamic field where the knowledge is continually enriched by conjecture, investigation, analysis, and/or justification.</li><li>Can identify student misconceptions and respectfully redirect students to develop accurate STE understanding.</li></ul></td></tr>
<tr><td colspan="2">2.3 Students learn science and technology/engineering when thoughtfully integrated laboratory and investigative experiences enhance student development of content knowledge, inquiry skills, and the design process.</td></tr>
<tr><td>The students:<ul><li>Can explain how the laboratory experience relates to prior learning activities (lectures, reading, discussion, activities).</li><li>Know what they are doing and why it is important.</li><li>Apply Scientific Inquiry Skills and/or the Engineering Design Process Skills to solve problems. The students:<ul><li>Identify a need or problem</li><li>Raise questions</li><li>Research the need or problem</li><li>Formulate a hypothesis/develop a solution and prototype</li><li>Design and execute experiments/test and evaluate solutions</li><li>Gather and analyze data</li><li>Construct scientific arguments and explanations</li><li>Clearly communicate findings and results</li><li>Apply learning to new problem/modify the solution and redesign.</li></ul></li></ul></td><td>The teacher:<ul><li>Designs laboratory experiences that have content, inquiry, and/or design process objectives.</li><li>Sequences the laboratory experience into the instructional unit to maximize student learning.</li><li>States the purpose of the laboratory and provides a rationale for the experience.</li><li>Facilitates follow-up discussion, analysis, and/or sense-making of the lab.</li></ul></td></tr>
</table>

<table>
<tr><td colspan="2">2.4 Students learn science and technology/engineering when lessons elicit student experience, prior knowledge, and misconceptions while addressing readiness and learning styles.</td></tr>
<tr><td>The students:<ul><li>Draw on their existing knowledge and their experience of the world around them to inform their learning.</li><li>Express their understandings and ideas in multiple modes.</li></ul></td><td>The teacher:<ul><li>Uses a pre-assessment to gauge students' level of understanding</li><li>Connects current student learning with objectives and concepts from previous and subsequent lessons.</li><li>Knows students' abilities, readiness, and learning styles and appropriately prepares learning opportunities.</li><li>Responds to individual student learning styles and interests.</li><li>Plans opportunities that require students to draw upon their existing knowledge.</li><li>Works collaboratively with other teachers to plan instruction (ex: ELL teachers, inclusion teachers, other science teachers).</li></ul></td></tr>
<tr><td colspan="2">2.5 Students learn science and technology/engineering when differentiated learning experiences support the range of learners in the classroom.</td></tr>
<tr><td>The students:<ul><li>Engage in a variety of activities targeted to help them learn the lesson objective(s).</li><li>Use technology to enhance their learning (ex: Probes; Internet; Digital Cameras).</li><li>Choose activities and assignments that most interest and engage them.</li><li>Engage in activities appropriate in terms of complexity and pacing for their current level of knowledge and skill, but which challenge them to move forward.</li></ul></td><td>The teacher:<ul><li>Accommodates different learning styles by including a variety of relevant learning activities in each lesson.</li><li>Provides opportunity for students to make choices about how (not what) they learn.</li><li>Selects appropriate group configurations and composition for the task and learning objective.</li><li>Provides clear guidelines and expectations for group work and holds students accountable for their contributions to group work.</li><li>Effectively takes advantage of teachable moments.</li><li>Provides students with multiple opportunities to demonstrate mastery.</li><li>Uses instructional technology to enhance student learning opportunities.</li></ul></td></tr>
<tr><td colspan="2">2.6 Students learn science and technology/engineering when formative assessments and student responses to probing questions inform instructional decisions.</td></tr>
<tr><td>The students:<ul><li>Ask for teacher input and help.</li><li>Respond thoughtfully to questions from the teacher and other students.</li><li>Convey a sense that the lesson is of an appropriate level of rigor or challenge.</li></ul></td><td>The teacher:<ul><li>Asks open-ended questions.</li><li>Scaffolds student thinking and explanation through sequenced questions.</li><li>Uses student responses to direct discussions and inform instruction.</li><li>Re-teaches based on student input and response.</li></ul></td></tr>
</table>

# III. Student Expectations

| 3.1 Students learn science and technology/engineering when the learning objective(s) of each lesson are evident and clear to all students. | |
|---|---|
| The students:<br>• Easily locate learning objectives (on an agenda, poster, handout, etc).<br>• Know what constitutes a high quality product by referring to descriptions (written or oral, in age-appropriate language), rubrics, or exemplary work. | The teacher:<br>• Posts the STE standards-based lesson objective(s) in age-appropriate, student-friendly language.<br>• Makes specific verbal reference to the standards that students are expected to understand.<br>• Develops rubrics that communicate what the students should know and be able to do.<br>• Provides concrete examples or exemplary products (teacher generated, student generated, or both) that represent mastery |
| 3.2 Students learn science and technology/engineering when all students are expected to participate and demonstrate their learning of the learning objective(s). | |
| The students:<br>• Revise and edit work to meet expectations.<br>• Spend the majority of class time developing new knowledge and skills.<br>• Engage in learning opportunities available in the lesson. | The teacher:<br>• Expects all students to master the learning objectives of the lesson.<br>• Provides all students, regardless of current knowledge, entry into the lesson.<br>• Holds all students accountable for completing work, participating, and learning.<br>• Provides all students with accurate and constructive feedback, explicitly guiding continuous student progress toward mastery of the standard(s).<br>• Allows all students multiple opportunities to demonstrate proficiency.<br>• Uses wait-time effectively to allow all students meaningful participation. |

# IV. An Environment for Learning

<table>
<tr><td colspan="2">4.1 Students learn science and technology/engineering when the classroom atmosphere is orderly, respectful, and focused on student learning.</td></tr>
<tr><td>The students:<ul><li>Use respectful and appropriate language in the classroom.</li><li>Demonstrate respect for property and materials.</li><li>Begin work when they enter the room.</li><li>Know the goal(s) of the lesson and work toward meeting the objective(s).</li><li>Follow classroom routines well enough that minimal time is spent on receiving directions.</li><li>Transition smoothly between learning activities.</li><li>Feel comfortable asking questions and contributing throughout the lesson.</li><li>Demonstrate positive, respectful relationships (student—teacher or student—student).</li></ul></td><td>The teacher:<ul><li>Establishes a consistent lesson structure (ex: activator or bell work to open the lesson; a summary for closure; a ticket out the door for assessment).</li><li>Facilitates learning rather than directs.</li><li>Establishes clear standards for student conduct and teaches appropriate behavior.</li><li>Responds appropriately to misbehavior.</li><li>Spends minimal time on organizational details (e.g., attendance, distribution of supplies).</li><li>Displays student work related to the STE standards and learning objectives.</li><li>Models positive, respectful, and appropriate language and behavior.</li><li>Encourages students to share their thinking and pose questions.</li><li>Keeps students focused on learning objectives.</li></ul></td></tr>
<tr><td colspan="2">4.2 Students learn science and technology/engineering when students are physically safe.</td></tr>
<tr><td>The students:<ul><li>Safely use equipment and materials.</li><li>Know what to do in an emergency.</li><li>Monitor one another for safety practices.</li><li>Understand the elements of the school safety contract.</li></ul></td><td>The teacher:<ul><li>Provides clear access to the eyewash, safety shower, and other classroom safety equipment.</li><li>Models safety practices, including wearing appropriate safety equipment and apparel.</li><li>Actively monitors and comments on students' safety practices.</li><li>Prepares students for any potential hazards before an activity, lab, or demonstration.</li><li>Knows what to do in an emergency.</li></ul></td></tr>
</table>

# V. Documentation and Communication of Student Learning

<table>
<tr><td colspan="2">5.1 Students learn science and technology/engineering when classroom assessment systems document the progress of student learning toward each standard.</td></tr>
<tr><td>The students:<ul><li>Know that their grade reflects their level of mastery relative to the standard.</li><li>Can explain the system used to document their progress.</li></ul></td><td>The teacher:<ul><li>Uses the standards to establish and publish assessment criteria.</li><li>Consistently documents student progress toward learning the standard.</li><li>Uses students' performance toward the standard as the basis for grades.</li><li>Communicates students' progress and system for assessment to parents.</li></ul></td></tr>
<tr><td colspan="2">5.2 Students learn science and technology/engineering best when multiple types of formative and summative assessments are regularly used to gauge student understanding and provide feedback to students.</td></tr>
<tr><td>The students:<ul><li>Are aware of the learning objectives that are being assessed in the lesson and unit.</li><li>Receive feedback willingly.</li><li>Use feedback to focus future study and learning activities.</li><li>Can describe what topics they have mastered and what they need more work on.</li></ul></td><td>The teacher:<ul><li>Uses data from assessments to inform instruction.</li><li>Monitors student understanding using frequent assessments, including:<ul><li>Student responses to questions</li><li>Group interactions</li><li>Student work</li><li>Student/group presentations</li><li>Journals/written-reflections</li><li>Student projects</li><li>Student explanations of activities or labs</li><li>Tests and quizzes.</li></ul></li><li>Provides students with timely feedback regarding their understanding of and progress toward learning the standards.</li><li>Provides additional, targeted learning opportunities to meet student needs (for intervention and enrichment).</li></ul></td></tr>
</table>