STEM Education Overview

What is STEM Education?

- An approach to teaching and learning that integrates the content and skills of the STEM disiciplines and other disciplines to answer complex questions, investigate global issues, and solve real-world problems and challenges.

Why STEM Education?

- To inspire and prepare Maryland's students to be both college and career ready and STEM proficient members of society in order to prepare generations of learners to meet the challenges of the global society through innovation, collaboration, and creative problem solving.

How to Implement STEM Education?

- STEM Standards of Practice (SOPs) and Frameworks
- STEM-centric units, lessons, and experiences
- Project-, problem-, inquiry-, and challenged-based pedagogies
- Professional Learning Communities (PLCs)

STEM In Maryland

STEM Education is an approach to teaching and learning that integrates the content and skills of the STEM disciplines and other disciplines to answer complex questions, investigate global issues, and solve real-world problems and challenges to prepare students for post-secondary study and the 21st century workforce.

STEM Standards of Practice define STEM instruction by defining the combination of behaviors, integrated with STEM content, which are expected of STEM-proficient students.

STEM Standards of Practice Frameworks identify what students must know and be able to do to demonstrate STEM proficiency.

STEM Education Definition

STEM education is an approach to teaching and learning that integrates the content and skills of science, technology, engineering, and mathematics. STEM Standards of Practice guide STEM instruction by defining the combination of behaviors, integrated with STEM content, which is expected of a proficient STEM student. These behaviors include engagement in inquiry, logical reasoning, collaboration, and investigation. The goal of STEM education is to prepare students for post-secondary study and the 21st century workforce.

Maryland State STEM Standards of Practice

1. **Learn and Apply Rigorous Science, Technology, Engineering, and Mathematics Content**

   STEM proficient students will learn and apply rigorous content within science, technology, engineering, and mathematics disciplines to answer complex questions, to investigate global issues, and to develop solutions for challenges and real world problems.

   A. Demonstrate an understanding of science, technology, engineering, and mathematics content.

   B. Apply science, technology, engineering, or mathematics content to answer complex questions, to investigate global issues, and to develop solutions for challenges and real world problems.

2. **Integrate Science, Technology, Engineering, and Mathematics Content**

   STEM proficient students will integrate content from science, technology, engineering, and mathematics disciplines as appropriate to answer complex questions, to investigate global issues, and to develop solutions for challenges and real world problems.

   A. Analyze interdisciplinary connections that exist within science, technology, engineering, and mathematics disciplines and other disciplines.

   B. Apply integrated science, technology, engineering, mathematics content, and other content as appropriate to answer complex questions, to investigate global issues, and to develop solutions for challenges and real world problems.

3. **Interpret and Communicate Information from Science, Technology, Engineering, and Mathematics**

   STEM proficient students will interpret and communicate information from science, technology, engineering, and mathematics to answer complex questions, to investigate global issues, and to develop solutions for challenges and real world problems.

   A. Identify, analyze, and synthesize appropriate science, technology, engineering, and mathematics information (text, visual, audio, etc.).
   B. Apply appropriate domain-specific vocabulary when communicating science, technology, engineering, and mathematics content.
   C. Engage in critical reading and writing of technical information.
   D. Evaluate and integrate multiple sources of information (e.g.: quantitative data, video and multimedia) presented in diverse formats.
   E. Develop an evidence-based opinion or argument.
   F. Communicate effectively and precisely with others.

4. **Engage in Inquiry**

   STEM proficient students will engage in inquiry to investigate global issues, challenges, and real world problems.

   A. Ask questions to identify and define global issues, challenges, and real world problems.
   B. Conduct research to refine questions and develop new questions.

5. **Engage in Logical Reasoning**

   STEM proficient students will engage in logical reasoning to answer complex questions, to investigate global issues, and to develop solutions for challenges and real world problems.

   A. Engage in critical thinking.
   B. Evaluate, select, and apply appropriate systematic approaches (scientific and engineering practices, engineering design process, and/or mathematical practices).
   C. Apply science, technology, engineering, and mathematics content to construct creative and innovative ideas.
   D. Analyze the impact of global issues and real world problems at the local, state, national, and international levels.

6. **Collaborate as a STEM Team**

   STEM proficient students will collaborate as a STEM team to answer complex questions, to investigate global issues, and to develop solutions for challenges and real world problems.

   A. Identify, analyze, and perform a STEM specific subject matter expert (SME) role.
   B. Share ideas and work effectively with a STEM focused multidisciplinary team to achieve a common goal.
   C. Listen and be receptive to ideas of others.
   D. Analyze career opportunities that exist in a variety of STEM fields relevant to the STEM focused multidisciplinary team's goal.

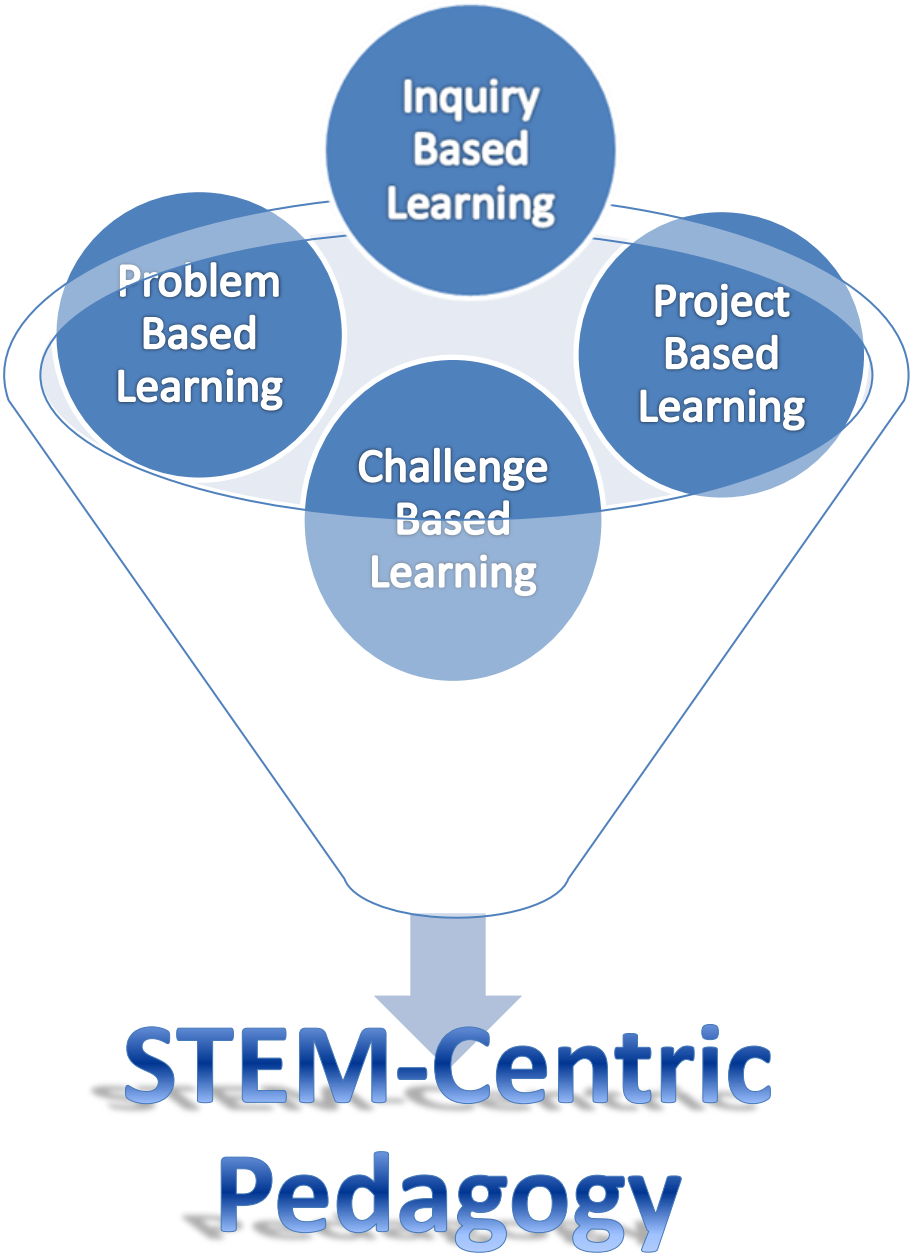
7. **Apply Technology Strategically**

   STEM proficient students will apply technology appropriately to answer complex questions, to investigate global issues, and to develop solutions for challenges and real world problems.

   A. Identify and understand technologies needed to develop solutions to problems or construct answers to complex questions.
   B. Analyze the limits, risks, and impacts of technology.
   C. Engage in responsible/ethical use of technology.
   D. Improve or create new technologies that extend human capability.

STEM-Centric Pedagogy

Problem-Based (Challenge Based)	Inquiry-Based	Project-Based
• Problem-based or challenge based instruction serves to teach content by presenting the students with a real-world challenge similar to one they might encounter were they a practitioner of the discipline. Teaching content through skills is one of the primary distinguishing features of problem-based learning. Retrieved from: http://www.pbl.uci.edu/whatispbl.html	• Inquiry-based instruction is a student-centered and teacher-guided instructional approach that engages students in investigating real world questions that they choose within a broad thematic framework. Inquiry-based instruction complements traditional instruction by providing a vehicle for extending and applying the learning of students in a way that connects with their interests within a broader thematic framework. Students acquire and analyze information, develop and support propositions, provide solutions, and design technology and arts products that demonstrate their thinking and make their learning visible. Retrieved From: http://www.neiu.edu/	• In project-based learning students go through an extended process of inquiry in response to a complex question, problem, or challenge. Rigorous projects help students learn key academic content and practice 21st Century Skills (such as collaboration, communication & critical thinking). Retrieved from: http://www.bie.org/


Inquiry Based Learning
Problem Based Learning
Project Based Learning
Challenge Based Learning
STEM-Centric Pedagogy

Attributes of a STEM-Centric Learning Environment

The attributes of a STEM-Centric Learning Environment identifies key components of a STEM focused classroom.

Pedagogy and Curriculum……	Teachers……	Students……
is project-, problem -, challenged - and/or inquiry - based	collaborate with educators in other disciplines to develop integrated lessons.	understand and can describe the relationship between content topics, the real world connection, and the work performed by STEM professionals.
is transdisciplinary	facilitate student engagement and questioning – this includes asking question that promote higher order thinking and guiding students through the problem solving process.	are actively engaged in questioning, problem solving, and hands-on activities.
incorporates content standards and the STEM Standards of Practice.	involve students in the real world application of content.	collaborate and function as subject matter experts to address the real world connection.
incorporates content standards from multiple disciplines to address the real world connection.	provide opportunities for students to design and conduct investigations to address the real world connection.	design and conduct investigations to address the real world connection.
focuses teaching and learning on developing content mastery and STEM proficiency.	facilitate learning experiences that allow for the intentional and purposeful integration and application of content.	are able to employ systematic approaches (e.g.: engineering design process) to address the real world connection.
incorporates differentiation strategies to address the needs of diverse learners.	provide support to students in their use of technology for exploration of the real world connection.	are able to use the necessary and available technology required to address the real world connection.
	conduct ongoing assessments of students' performance, both formally and informally, to guide instruction and raise the quality of teaching.	effectively communicate ideas, data, design products, conclusions, results, etc. to diverse audiences.

Real World Connection - A complex question, global issue, challenge, or problem with real world relevance.

Maryland STEM
Units Components

This document is designed to aid educators in designing STEM centric units for any content area. The items listed below describe the components of a STEM unit.

Title. This is descriptive statement about the unit.

Overview. This is a summary of what students will learn in the unit. It explains the unit's focus and real world connection.

Enduring Understandings. These go beyond discrete facts or skills to focus on larger concepts, principles, or processes. They are transferable—applicable to new situations within or beyond the subject.

Essential Questions. Essential questions are open-ended questions that provoke inquiry about the core ideas for the unit. They are grade-level appropriate questions that prompt intellectual exploration of a topic.

Content Standards. This section will list Maryland State Curriculum content standards from multiple disciplines that are addressed in the unit.

STEM Standards of Practice. This section identifies the essential skills and knowledge from STEM Standards of Practice that will be addressed in the unit.

Clarifications/Examples. This component will provide extensions of the essential skills and knowledge and core learning goal indicators found in the Maryland State Curriculum. These extensions will include examples as appropriate.

Connection to STEM Careers. This section describes careers in the STEM fields that correlate with content covered in the unit.

Transdisciplinary Connections. This section will broadly list the content areas the unit covers and suggest opportunities for real world connections between Science, Technology, Engineering, Mathematics, and other disciplines.

Suggested Student Outcomes. These are the specific student outcomes for the unit and are aligned with but not limited to Maryland State Curriculum in Science, Technology, Engineering, and Mathematics. They describe the transferable knowledge and skills that students should understand and be able to do when the unit is completed. The outcomes are often components of more broadly-worded standards and sometimes address knowledge and skills not necessarily related to the standards. The lists of outcomes are not exhaustive, and the outcomes should not supplant the standards themselves. Rather, they are designed to help teachers "drill down" from the standards and augment as necessary, providing added focus and clarity for lesson planning purposes.

Vocabulary/Terminology/Concepts. These are concepts and terms that will be encountered—often for the first time—over the course of the unit. The list is not comprehensive; it is meant to highlight terms that either are particular to the unit, are introduced there, or that play a large role in the work or content of the unit. These terms and concepts are usually implied by the standards, but not always made explicit in them.

Common Misconceptions. This component will provide insights into areas that have historically presented challenges for both the teacher providing the instruction and the student understanding the concept.

Key Advances from Previous Grades/Courses. Statements about what was learned in previous grades/course that will support student learning.

Sample Lesson Plan. Outlined below are components of a STEM lesson plan.

- Lesson Title
- Grade Level
- Subject Areas
- Estimated Time
- Content Standards
- STEM Standards of Practice Essential Skills and Knowledge
- Lesson Overview
- Essential Questions
- Student Outcomes
- Suggested Materials
- Essential Background Knowledge
- STEM Career Connections
- Performance Based Formative Assessments with Rubrics
- 5E Model
- Differentiation - ELL, GT, Special education, 508, UDL

Lesson Seeds. The lesson seeds are ideas that can be used to build a lesson. They are designed to generate evidence of student understanding and give teachers ideas for developing their own activities. Lesson seeds are not meant to be all-inclusive, nor are they substitutes for instruction.

Additional Resources. These are links to media, lesson plans, activities, related background information and other instructional materials for teachers from a variety of sources.

Interventions/Enrichments. Modules or links

Creating a STEM Centric Learning Experience

The diagram below outlines the approach for creating a STEM centric learning experience in any content area.

Content Standards and STEM Standards of Practice

Select standards from a core content area that will be addressed in the lesson. For example, a math teacher would select from math standards. STEM Standards of Practice are designed to complement content standards. As a result, STEM Standards of Practice would be used with the selected content standards to guide the instructional approach.

Real World Connections

Develop a complex question or identify a global issue, challenge, or real world problem that relates to content standards.

Have students develop a complex question or identify a global issue, challenge, or real world problem that relates to a content topic or learning activity.

Connection to Science, Technology, Engineering, and Mathematics

Select standards and skills from science, technology, mathematics, and engineering that are necessary for answering the proposed complex question, investigating the global issue, or developing solutions to a challenge or real world problem. Collaboration and instructional support may be needed to successfully identify and implement standards from the STEM disciplines.

STEM Career Connections

Describe STEM careers that relate to content topics or learning activities.

Allow students to research STEM careers that relate to content topics or learning activities.

5E Model for Integrated STEM Instruction

Use the 5E Model to design learning activities and performance - based assessments. Incorporate Universal Design for Learning Principles, WIDA Performance Definitions and CAN DO Descriptors, and accelerations or enhancements to engage learners of diverse academic backgrounds.

Creating a STEM-Centric Learning Experience

Brainstorming Template

orming approach for creating a STEM-centric Experience

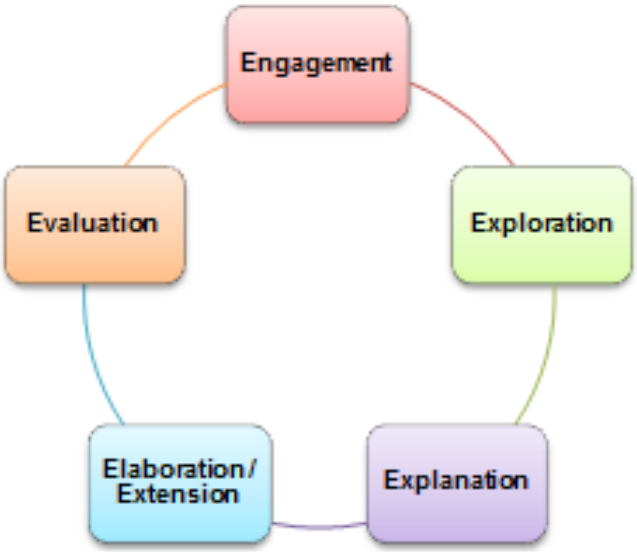
e: _____

Content Standards and STEM Standards of Practice Identify content standards that will be addressed in the unit. STEM Standards of Practice are used with content standards to guide the instructional approach.	
Real World Connections Develop a complex question or identify a global issue, challenge, or real world problem that relates to content standards.	
Connection to Science, Technology, Engineering, and Mathematics Select standards and skills from science, technology, engineering, and/or mathematics disciplines that are necessary for addressing the real world connection.	
STEM Career Connections - Identify STEM careers that relate to content topics or learning activities. - Allow students to research identified STEM careers.	
5E Model for Integrated STEM Instruction - Include multiple lesson topics that can be used to support students' understanding of content and the real world connection. - Describe the product, model, or action students will produce or perform to address the real world connection.	

*This organizer was developed by Frederick County Public School's Department of STEM and adapted with permission for use by the Maryland State Department of Education.

5E Model for Integrated STEM Instruction

The 5E model for integrated STEM instruction promotes the development of new understandings by building on prior experiences. The five stages of learning in the 5E model are Engagement, Exploration, Explanation, Elaboration / Extension, and Evaluation. The 5E model is not linear and evaluation typically occurs throughout the 5E cycle. It may take several days or several lessons to complete a 5E cycle.



	Description
Engagement	• Teacher or student poses a real world problem, challenge, complex question, or global issue that relates to the content standards to be address in the lesson. • Students brainstorm potential solutions or explanations.
Exploration	Students • explore and make connections between science, technology, engineering, and mathematics. • select and apply the appropriate systematic approaches to answer complex questions, to investigate global issues, and to develop solutions for challenges and for real world problems.
Explanation	Students • analyze and interpret data. • communicate understandings and possible solutions. • use technology appropriately for analysis and communication.
Elaboration / Extension	Students • refine solutions, prototypes, and/or models. • modify experimental procedures for further exploration. • identify and analyze connections to STEM careers.
Evaluation	Students • reflect on their answers or solutions to the complex question, issue, challenge or problem. • participate in peer reviews. • demonstrate understanding through performance-based tasks.

Universal Design for Learning Guidelines

I. Provide Multiple Means of Representation

1. Provide options for perception

- Options that customize the display of information
- Options that provide alternatives for auditory information
- Options that provide alternatives for visual information

2. Provide options for language and symbols

- Options that define vocabulary and symbols
- Options that clarify syntax and structure
- Options for decoding text or mathematical notation
- Options that promote cross-linguistic understanding
- Options that illustrate key concepts non-linguistically

3. Provide options for comprehension

- Options that provide or activate background knowledge
- Options that highlight critical features, big ideas, and relationships
- Options that guide information processing
- Options that support memory and transfer

II. Provide Multiple Means of Action and Expression

4. Provide options for physical action

- Options in the mode of physical response
- Options in the means of navigation
- Options for accessing tools and assistive technologies

5. Provide options for expressive skills and fluency

- Options in the media for communication
- Options in the tools for composition and problem solving
- Options in the scaffolds for practice and performance

6. Provide options for executive functions

- Options that guide effective goal-setting
- Options that support planning and strategy development
- Options that facilitate managing information and resources
- Options that enhance capacity for monitoring progress

III. Provide Multiple Means of Engagement

7. Provide options for recruiting interest

- Options that increase individual choice and autonomy
- Options that enhance relevance, value, and authenticity
- Options that reduce threats and distractions

8. Provide options for sustaining effort and persistence

- Options that heighten salience of goals and objectives
- Options that vary levels of challenge and support
- Options that foster collaboration and communication
- Options that increase mastery-oriented feedback

9. Provide options for self-regulation

- Options that guide personal goal-setting and expectations
- Options that scaffold coping skills and strategies
- Options that develop self-assessment and reflection

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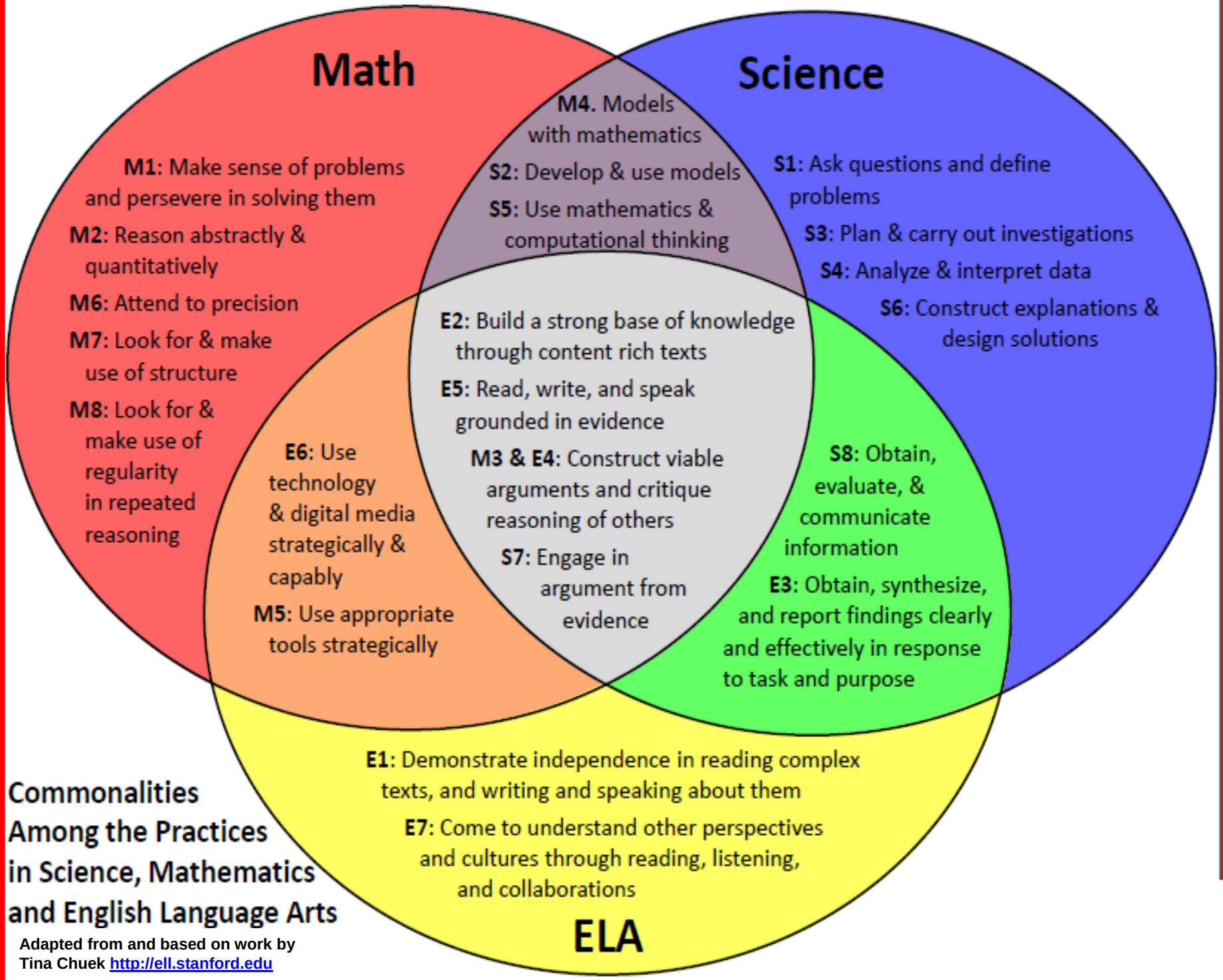
STEM STANDARDS OF PRACTICE



STEM STANDARDS OF PRACTICE

Commonalities Among the Practices in Science, Mathematics and English Language Arts

Adapted from and based on work by Tina Chuek http://ell.stanford.edu

Practices in Mathematics, Science, and English Language Arts*

Math	Science	English Language Arts
M1. Make sense of problems and persevere in solving them.	**S1.** Asking questions (for science) and defining problems (for engineering).	**E1.** They demonstrate independence.
M2. Reason abstractly and quantitatively.	**S2.** Developing and using models.	**E2.** They build strong content knowledge.
M3. Construct viable arguments and critique the reasoning of others.	**S3.** Planning and carrying out investigations.	**E3.** They respond to the varying demands of audience, task, purpose, and discipline.
M4. Model with mathematics.	**S4.** Analyzing and interpreting data.	**E4.** They comprehend as well as critique.
M5. Use appropriate tools strategically.	**S5.** Using mathematics, information and computer technology, and computational thinking.	**E5.** They value evidence.
M6. Attend to precision.	**S6.** Constructing explanations (for science) and designing solutions (for engineering).	**E6.** They use technology and digital media strategically and capably.
M7. Look for and make use of structure.	**S7.** Engaging in argument from evidence.	**E7.** They come to understanding other perspectives and cultures.
M8. Look for and express regularity in repeated reasoning.	**S8.** Obtaining, evaluating, and communicating information.	

S T M E

- **The Common Core English Language Arts uses the term "student capacities" rather than the term "practices" used in Common Core Mathematics and the Next Generation Science Standards.**
- **Like the bold, red frame surrounding the table above, the STEM Standards of Practice literally surround and support the practices in Mathematics, Science, and English Language Arts.**

STEM Education

STEM education is an approach to teaching and learning that integrates the content and skills of science, technology, engineering, and mathematics. STEM Standards of Practice guide STEM instruction by defining the combination of behaviors, integrated with STEM content, which is expected of a proficient STEM student. These behaviors include engagement in inquiry, logical reasoning, collaboration, and investigation. The goal of STEM education is to prepare students for post-secondary study and the 21st century workforce.

STEM Centric Lesson and Unit Checklist Overview

The STEM Centric Lesson and Unit Checklist was created to provide support for educators in the development or modification of lessons and units. A STEM centric lesson or unit incorporates the STEM Standards of Practice and reflects the definition of STEM education. The attached checklist describes four components to consider when developing or modifying a lesson or unit – content standards and the STEM Standards of Practice, real world connection, development of deep conceptual understandings, and diverse learners. Each component contains criteria represented in a fully developed STEM centric lesson or unit. Criterion should only be checked if the lesson or unit contains evidence of the criterions' descriptor. All criteria should be checked in a fully developed STEM centric lesson or unit.

Using the STEM Centric Lesson and Unit Checklist

The STEM Centric Lesson and Unit Checklist should be used as a tool to aid in the development or modification of units and lessons to reflect the definition of STEM Education and incorporate the STEM Standards of Practice. This document should be used as a self-reflection tool and a resource to help guide STEM instruction. Further, educators can use the checklist to identify areas of improvement and sustainability in a lesson or unit. This document is not intended to be used for the purposes of teacher evaluation or a "look for" when conducting classroom visits.

STEM Centric Lesson and Unit Checklist

Lesson or Unit Title:
Course(s):

Content Standards and the STEM Standards of Practice	Real World Connection	Development of Deep Conceptual Understandings	Diverse Learners
The lesson or unit: ☐ Aligns to a target set of rigorous course content standards. Identify content standards below: ☐ Aligns to the STEM Standards of Practice. Identify Practices below: ☐ Integrates content standards from science, technology, engineering, or mathematics courses as appropriate to address the real world connection. Identify standards below: ☐ Focuses teaching and learning on developing content mastery and STEM proficiency.	*The lesson or unit:* ☐ Presents the real world connection in the form of a complex question, global issue, challenge, or problem. ☐ Provides opportunities for students to apply content knowledge from multiple courses as appropriate to answer complex questions, to investigate global issues, or to develop solutions for challenges and real world problems. ☐ Provides opportunities for students to develop or use a systematic approach (e.g.: engineering design process, computational thinking) to investigate and develop solutions or answers to the real world connection. ☐ Provides opportunities for students to understand the relationship between the real world connection, course content, and the work performed by STEM professionals.	*The lesson or unit:* ☐ Requires students to employ higher order thinking skills in the application of content knowledge. ☐ Provides opportunities for students to adapt or extend concepts, activities, or projects to enhance their understanding. ☐ Provides opportunities for students to develop understanding of content through questioning, problem solving, collaboration, and hands-on activities. ☐ Provides opportunities for students to demonstrate their understanding of content and the application of the STEM Standards of Practice independently (this check box is for a unit containing multiple lessons).	*The lesson or unit incorporates the following as appropriate to meet the needs of diverse learners:* ☐ Universal Design for Learning Principals http://marylandlearninglinks.org/950 ☐ WIDA Performance Definitions and CAN DO Descriptors http://www.wida.us/standards/CAN_DOs/ ☐ Accelerations or enhancements for gifted and talented students.

Note about assessments: Assessments should be given regularly throughout a lesson or unit to collect evidence of student learning and raise the quality of teaching. Assessments should be varied, aligned to instructional outcomes, designed to measure progress towards mastery of content and STEM proficiency, and include rubric-based performance tasks that are relevant to the real world of work. The unit or lesson should provide students multiple opportunities to demonstrate mastery of content and STEM proficiency.

Works Consulted:

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