**Subject Matter Knowledge Matrix**

**Early Childhood, PK-2**

Students in Massachusetts must meet rigorous academic standards, which are outlined in the [Massachusetts Curriculum Frameworks](https://www.doe.mass.edu/frameworks/). To do so, they must have access to educators with strong content knowledge and pedagogical skills, the building blocks of effective instructional practice.

In support of this, the [Subject Matter Knowledge Guidelines](https://www.doe.mass.edu/edprep/domains/instruction/smk-guidelines.docx) set forth the content knowledge expectations for educator licensure in Massachusetts. Through these expectations, the Massachusetts Department of Elementary and Secondary Education (DESE) seeks to ensure that educators entering the workforce have sufficient content knowledge in their licensure area to support students in mastering the Massachusetts Curriculum Frameworks.

While the Curriculum Frameworks serve as an anchor, the intent is not that educators should simply know the content included in the Frameworks. Rather, educators must move beyond basic or functional knowledge to a level of fluency or expertise with the academic standards such that they can teach and support students in mastering the content.

The figure below shows a steady progression, not in the amount of information one knows, but in the depth and ability to use that information for a specific purpose. The boxes below the continuum outline some assessments used to determine varying levels of content knowledge. The depth at which the knowledge and application of content knowledge must be demonstrated is dependent on the stage of development for an individual educator (i.e. Basic, Functional, Fluent, or Expert) and/or license type (Provisional, Initial, or Professional).



This worksheet should be completed for Early Childhood, PK-2 programs, for which Subject Matter Knowledge expectations come from multiple [Curriculum Frameworks](https://www.doe.mass.edu/frameworks/). Within this document you will find sections covering the following SMK expectations:

[English Language Arts and Literacy](#_English_Language_Arts)

* English Language Arts and Literacy Anchor Standards
* English Language Arts and Literacy Practices

[History and Social Science](#_History_and_Social)

* History and Social Science Scope, Sequence, and Content Progression
* Standards for History and Social Science Practices

[Mathematics](#_Mathematics_Content_Progression)

* Mathematics Content Progression
* Mathematical Rigor
* Standards for Mathematics Practices

[Science and Technology/Engineering](#_Science_and_Technology/Engineering)

* Science and Technology/Engineering Content Progression
* Science and Technology/Engineering Practices

# English Language Arts and Literacy Anchor Standards

The English Language Arts and Literacy Anchor Standards define general, cross-disciplinary literacy expectations that must be met for PK-12 students to be prepared to enter college and the workforce ready to succeed.

To create a strong vertical progression of learning, educators should have the content knowledge to support PK-12 students in mastering the anchor standards across grade levels. Teachers need to be able to access knowledge from prior grades, and teachers who are aware of later content can make better choices about what to emphasize, what language to use, and what larger contexts to provide for their students. This expectation allows teachers to meet students where they are and prepare them for where they are going.

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| **Instructions*:***The content knowledge below must either be covered directly through program coursework or screened during the admissions process. For each row, list the numbers/abbreviations/titles of the **sponsoring organization’s required courses where the anchor standards are explicitly targeted and coherently addressed**. Then, **briefly describe where in the syllabus each anchor standard is covered** (i.e., unit name, week number, objective number). Course identifiers should match those of submitted syllabi and content knowledge for each grade level should not be spread across too many courses.    The PK-12 grade-specific standards found in the full [English Language Arts and Literacy Curriculum Framework](https://www.doe.mass.edu/frameworks/current.html) define end-of-year expectations for each grade level relative to the anchor standards. As such, the Framework, including the Guiding Principles which are also available in Appendix A of this document, should be consulted when designing programs to ensure appropriate content coverage and rigor for each licensure field’s grade span. sponsoring organizations should prioritize content fluency in the grade span for the license while ensuring functional content knowledge in the two grade levels below and above the grade span. |

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| **Key Ideas and Details** | **Course(s) or Screening** |
| *Example Row* | *EDU 101 – Weeks 5-7* |
| **Reading 1.** Read closely to determine what a text states explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from a text. |  |
| **Reading 2.** Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas. |  |
| **Reading 3.** Analyze how and why individuals, events, and ideas develop and interact over the course of a text. |  |
| **Craft and Structure** | **Course(s) or Screening** |
| **Reading 4.** Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone. |  |
| **Reading 5.** Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of a text relate to each other and the whole. |  |
| **Reading 6.** Assess how point of view or purpose shapes the content and style of a text. |  |
| **Integration of Knowledge and Ideas** | **Course(s) or Screening** |
| **Reading 7.** Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words. |  |
| **Reading 8.** Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence. |  |
| **Reading 9.** Analyze how two or more texts address similar themes or topics to build knowledge or to compare the approaches the authors take. |  |
| **Reading 10.** Independently and proficiently read and comprehend complex literary and informational texts. |  |
| **Text Types and Purposes** | **Course(s) or Screening** |
| **Writing 1.** Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. |  |
| **Writing 2.** Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. |  |
| **Writing 3.** Write narratives to develop experiences or events using effective literary techniques, well-chosen details, and well-structured sequences. |  |
| **Production and Distribution of Writing** | **Course(s) or Screening** |
| **Writing 4.** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |  |
| **Writing 5.** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach. |  |
| **Writing 6.** Use technology to produce and publish writing and to interact and collaborate with others. |  |
| **Research to Build and Present Knowledge** | **Course(s) or Screening** |
| **Writing 7.** Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation. |  |
| **Writing 8.** When conducting research, gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism. |  |
| **Writing 9.** Draw evidence from literary or informational texts to support analysis, interpretation, reflection, and research. |  |
| **Range of Writing** | **Course(s) or Screening** |
| **Writing 10.** Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences. |  |
| **Comprehension and Collaboration** | **Course(s) or Screening** |
| **Speaking and Listening 1.** Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others’ ideas and expressing their own clearly and persuasively. |  |
| **Speaking and Listening 2.** Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally. |  |
| **Speaking and Listening 3.** Evaluate a speaker’s point of view, reasoning, and use of evidence and rhetoric. |  |
| **Presentation of Knowledge and Ideas** | **Course(s) or Screening** |
| **Speaking and Listening 4.** Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, vocabulary, and style are appropriate to task, purpose, and audience. |  |
| **Speaking and Listening 5.** Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations. |  |
| **Speaking and Listening 6.** Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate. |  |
| **Conventions of Standard English** | **Course(s) or Screening** |
| **Language 1.** Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. |  |
| **Language 2.** Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. |  |
| **Knowledge of Language** | **Course(s) or Screening** |
| **Language 3.** Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening. |  |
| **Vocabulary Acquisition and Use** | **Course(s) or Screening** |
| **Language 4.** Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate. |  |
| **Language 5.** Demonstrate understanding of figurative language, word relationships, and nuances in word meanings. |  |
| **Language 6.** Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge |  |

# English Language Arts and Literacy Practices

The English Language Arts and Literacy Practices describe abilities that English educators at all levels should seek to develop in their PK-12 students. They are not standards themselves but instead offer a portrait of students who meet the standards set out in this document and are ready for college, careers, and civic participation. These practices complement the content standards so that students increasingly engage with the subject matter as they grow in maturity and expertise throughout the elementary, middle, and high school years.

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| **Instructions*:***Initial licensure program candidates must reach a level of fluent content knowledge to be endorsed. They must be able to apply content in a range of contexts and vertically connect content to build students’ knowledge. As such, sponsoring organizations must have at least one course covering the practices at the fluent level.    Please list the numbers/abbreviations/titles of the **required courses where practices are explicitly targeted and coherently addressed**. Then, **briefly describe where in the syllabus each practice is covered** (i.e., unit name, week number, objective number). Course identifiers should match those of submitted syllabi and practices should not be spread across too many courses. |

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| **English Language Arts and Literacy Practices** | **Fluent**  *Initial*  *Licensure* |
| *Example Row* | *EDU 101 – Weeks 5-7* |
| **1. Demonstrate independence.** Students can, without significant scaffolding, comprehend and evaluate complex texts across a range of types and disciplines, and they can construct effective arguments and convey intricate or multifaceted information. Likewise, students are able independently to discern a speaker’s key points, request clarification, and ask relevant questions. They build on others’ ideas, articulate their own ideas, and confirm they have been understood. Without prompting, they demonstrate command of standard English and acquire and use a wide-ranging vocabulary. More broadly, they become self-directed learners, effectively seeking out and using resources to assist them, including teachers, peers, and print and digital reference materials. |  |
| **2. Build strong content knowledge**. Students establish a base of knowledge across a wide range of subject matter by engaging with works of quality and substance. They become proficient in new areas through research and study. They read purposefully and listen attentively to gain both general knowledge and discipline-specific expertise. They refine and share their knowledge through writing and speaking. |  |
| **3. Respond to the varying demands of audience, task, purpose, and discipline.** Students adapt their communication in relation to audience, task, purpose, and discipline. They set and adjust purpose for reading, writing, speaking, listening, and language use as warranted by the task. They appreciate nuances, such as how the composition of an audience should affect tone when speaking and how the connotations of words affect meaning. They also know that different disciplines call for different types of evidence (e.g., documentary evidence in history and experimental evidence in science). |  |
| **4. Comprehend as well as critique**. Students are engaged and open-minded—but discerning—readers and listeners. They work diligently to understand precisely what an author or speaker is saying, but they also question an author’s or speaker’s assumptions and premises and assess the veracity of claims and the soundness of reasoning. |  |
| **5. Value evidence**. Students cite specific evidence when offering an oral or written analysis or interpretation of a text. They use relevant evidence when supporting their own points in writing and speaking, making their reasoning clear to the reader or listener, and they constructively evaluate others’ use of evidence. |  |
| **6. Use technology and digital media strategically and capably.** Students employ technology thoughtfully to enhance their reading, writing, speaking, listening, and language use. They tailor their searches online to acquire useful information efficiently, and they integrate what they learn using technology with what they learn offline. They are familiar with the strengths and limitations of various technological tools and mediums and can select and use those best suited to their communication goals. |  |
| **7. Come to understand other perspectives and cultures.** Students appreciate that the twenty-first-century classroom and workplace are settings in which people from often widely divergent cultures and who represent diverse experiences and perspectives must learn and work together. Students actively seek to understand other perspectives and cultures through reading and listening, and they can communicate effectively with people of varied backgrounds. They evaluate other points of view critically and constructively. Through reading great classic and contemporary works of literature representative of a variety of periods, cultures, and worldviews, students can vicariously inhabit worlds and have experiences much different than their own. |  |

# History and Social Science Scope, Sequence, and Content Progression

The History and Social Science Scope, Sequence, and Content Progression outlines the core history and social science knowledge that students should learn from PK through grade 12.

In support of a strong vertical progression of learning, educators should have the content knowledge to support PK-12 students in mastering prerequisite and advanced standards. Teachers need to be able to access knowledge from prior grades, and teachers who are aware of later content can make better choices about what to emphasize, what language to use, and what larger contexts to provide for their students. This expectation allows teachers to meet students where they are and prepare them for where they are going.

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| **Instructions*:***The content knowledge below must either be covered directly through program coursework or screened during the admissions process. For each grade level, list the numbers/abbreviations/titles of the **sponsoring organization’s required courses where the content knowledge is explicitly targeted and coherently addressed**. Then, **briefly describe where in the syllabus the content is covered** (i.e., unit name, week number, objective number). Course identifiers should match those of submitted syllabi and content knowledge for each grade level should not be spread across too many courses.    The full [History and Social Science Curriculum Framework](https://www.doe.mass.edu/frameworks/current.html), including the Guiding Principles which are also available in Appendix A of this document, should be consulted when designing programs to ensure appropriate content coverage and rigor for each licensure field’s grade span. Sponsoring Organizations should prioritize content fluency in the grade span for the license while ensuring functional content knowledge in the two grade levels below and above the grade span. |

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| **History and Social Science Scope, Sequence, and Content Progression** | **Course(s) or Screening** |
| *Example Row* | *EDU 101 – Weeks 5-7* |
| **Pre-Kindergarten: Building a Foundation for Living, Learning, and Working Together.** Students are introduced to four major fields of social studies: civics (respecting one another, cooperating, and obeying appropriate rules); geography (understanding connections between places and people); history (recalling experiences); and economics (understanding working, buying, selling and trading things). |  |
| **Kindergarten: Many Roles in Living, Learning, and Working Together.** Students learn about classroom democracy, respect for one another, local geography, roles of people, national, state, and community traditions, and economics in the context of work and money. |  |
| **Grade 1: Leadership, Cooperation, Unity, and Diversity.** Students learn about leadership on many levels, the meaning of citizenship, and map types. They explore how the concepts of unity and diversity, respect for differences, and respect of self, shape life in the United States, and how people make choices about purchasing goods and services and saving resources. |  |
| **Grade 2: Global Geography - Places and Peoples, Cultures and Resources.** Students learn about global geography, looking at reasons why people settle in particular places, why they migrate, how they bring culture with them, and how they earn a living, exchange goods and services, and save for the future. |  |
| **Grade 3: Massachusetts, Home to Many Different People.** Students study Massachusetts and New England, beginning with their own city or town. They explore interactions among Native Peoples, European settlers and Africans, and learn about the Massachusetts people who led the American Revolution. The standards introduce students to the founding documents of Massachusetts and United States so that they may begin to discuss and apply ideas about self-government as they help develop codes of classroom rules, rights, and responsibilities. |  |
| **Grade 4: North American Geography and Peoples.** Students learn about North America (Canada, Mexico, and the United States) and its peoples from a geographic perspective. They learn about ancient civilizations on the continent and early European exploration as they expand map reading, mapmaking, and geographic reasoning skills introduced in grades 2 and 3. They apply concepts of how geography affects human settlement and resource use, and how the westward expansion of the United States created a modern nation of 50 states and 16 territories. |  |

# Standards for History and Social Science Practice

The Standards for History and Social Science Practice describe the processes and skills that history and social science educators at all levels should seek to develop in their PK-12 students. The practices encompass civic knowledge, dispositions, and skills and reflect the range of disciplinary skills often used by historians, political scientists, economists, geographers, and ordinary citizens. Designed for integration with the content standards, the seven practices encompass the processes of inquiry and research that are integral to a rich and robust social science curriculum and the foundation for active and responsible citizenship. All seven practices can be applied from PK–12 and across all social science disciplines.

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| **Instructions*:***Initial licensure program candidates must reach a level of fluent content knowledge to be endorsed. They must be able to apply content in a range of contexts and vertically connect content to build students’ knowledge. As such, sponsoring organizations must have at least one course covering the practices at the fluent level.    Please list the numbers/abbreviations/titles of the **required courses where practices are explicitly targeted and coherently addressed**. Then, **briefly describe where in the syllabus each practice is covered** (i.e., unit name, week number, objective number). Course identifiers should match those of submitted syllabi and practices should not be spread across too many courses. |

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| **Standards for History and Social Science Practice** | **Fluent**  *Initial*  *Licensure* |
| *Example Row* | *EDU 101 – Weeks 5-7* |
| **1. Demonstrate civic knowledge, skills, and dispositions.**   * Civic knowledge includes the core knowledge in the Content Standards relating to civics and government, economics, geography, and history. * Civic intellectual skills encompass knowing how to identify, assess, interpret, describe, analyze and explain matters of concern in civic life. * Civic participatory skills encompass knowing how to make and support arguments, use the political process to communicate with elected officials and representatives of government, and plan strategically for civic change. * Civic dispositions encompass values, virtues, and behaviors, such as respect for others, commitment to equality, capacity for listening, and capacity for communicating in ways accessible to others. |  |
| **2. Develop focused questions or problem statements and conduct inquiries**. The ability to develop focused research questions in history and social science or define the dimensions of a particular policy problem is central to learning in these disciplines. Students learn that each field in the social sciences (political scientist, economist, geographer, historian) has its own ways of defining questions. |  |
| **3. Organize information and data from multiple primary and secondary sources.** Student researchers gather and organize information from a variety of online, print, and other sources. In the history and social science fields, they pay close attention to whether the source is primary or secondary. Primary sources are documents written or created during the period under study (e.g., census data, a map, an interview, a speech, or an artifact such as a building, painting, or tool) and considered first-hand accounts. Secondary sources are later interpretations or commentaries based on primary sources. Often students will use primary and secondary sources together to compose an argument, because each source provides a different type of information. |  |
| **4. Analyze the purpose and point of view of each source; distinguish opinion from fact.** Students need exposure to readings that represent a variety of points of view in order to become discerning and critical readers. They need to be able to identify the purpose of a document and the point of view of its author. As students search primary sources for answers to questions, they begin to understand that eyewitness accounts of the same event can differ. |  |
| **5. Evaluate the credibility, accuracy, and relevance of each source.** Students investigating a question using online sources often find all too much material, some of it conflicting. The ability to be discerning and skeptical consumers of information is a crucial college, career, and civic skill. Students should learn how and why to assess, verify, and cite sources. |  |
| **6. Argue or explain conclusions, using valid reasoning and evidence.** The strength of an argument or explanation lies in its logical development of ideas, acknowledgement of counterclaims, and use of reliable supporting evidence. Effective arguments and explanations often go beyond text alone to include well-chosen and relevant visual elements such as photographs, maps, and displays of quantitative data. Students’ ability to adapt a presentation to the task, purpose, and audience and their ability to respond to questions are important skills for civic participation. |  |
| **7. Determine next steps and take informed action, as appropriate.** One of the main goals of teaching history and the social science is to provide opportunities for students to practice using the knowledge and skills that enable them to participate in civic life. For example, engaging in discourse about public policy beyond the classroom through social media, letters to the editor, oral presentations in public settings, or community service-learning projects. |  |

# Mathematics Content Progression

The Mathematics Content Progression outlines the core mathematical knowledge that students should learn from PK through grade 12. To create a strong vertical progression of learning, educators should have the content knowledge to support PK-12 students in mastering prerequisite and advanced content standards. Teachers need to be able to access knowledge from prior grades, and teachers who are aware of later content can make better choices about what to emphasize, what language to use, and what larger contexts to provide for their students. This expectation allows teachers to meet students where they are and prepare them for where they are going.

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| **Instructions*:***The content knowledge below must either be covered directly through program coursework or screened during the admissions process. For each grade level, list the numbers/abbreviations/titles of the **sponsoring organization’s required courses where the content knowledge is explicitly targeted and coherently addressed**. Then, **briefly describe where in the syllabus the content is covered** (i.e., unit name, week number, objective number). Course identifiers should match those of submitted syllabi and content knowledge for each grade level should not be spread across too many courses.    The full [Mathematics Curriculum Framework](https://www.doe.mass.edu/frameworks/current.html), including the Guiding Principles which are also available in Appendix A of this document, should be consulted when designing programs to ensure appropriate content coverage and rigor for each licensure field’s grade span. Sponsoring Organizations should prioritize content fluency in the grade span for the license while ensuring functional content knowledge in the two grade levels below and above the grade span. |

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| **Mathematics Content Progression** | **Course(s) or Screening** |
| *Example Row* | *EDU 101 – Weeks 5-7* |
| **Pre-kindergarten:** Activity time should focus on two critical areas: (1) developing an understanding of whole numbers to 10, including concepts of one-to-one correspondence, counting, cardinality (the number of items in a set), and comparison; and (2) recognizing two-dimensional shapes, describing spatial relationships, and sorting and classifying objects by one or more attributes. Relatively more learning time should be devoted to developing children’s sense of number as quantity than to other mathematics topics. |  |
| **Kindergarten:** Instructional time should focus on two critical areas: (1) representing, relating, and operating on whole numbers, initially with sets of objects; and (2) describing shapes and space. More learning time in kindergarten should be devoted to number than to other topics. |  |
| **Grade 1:** Instructional time should focus on four critical areas: (1) developing understanding of addition, subtraction, and strategies for addition and subtraction within 20; (2) developing understanding of whole number relationships and place value, including grouping in tens and ones; (3) developing understanding of linear measurement and measuring lengths as iterating length units; and (4) reasoning about attributes of, and composing and decomposing geometric shapes |  |
| **Grade 2:** Instructional time should focus on four critical areas: (1) extending understanding of base-ten notation; (2) building fluency with addition and subtraction; (3) using standard units of measure; and (4) describing and analyzing shapes. |  |
| **Grade 3**: Instructional time should focus on four critical areas: (1) developing understanding of multiplication and division and strategies for multiplication and division within 100; (2) developing understanding of fractions, especially unit fractions (fractions with numerator 1); (3) developing understanding of the structure of rectangular arrays and of area; and (4) describing and analyzing two-dimensional shapes. |  |
| **Grade 4:** Instructional time should focus on three critical areas: (1) developing understanding and fluency with multi-digit multiplication, and developing understanding of dividing to find quotients involving multi-digit dividends; (2) developing an understanding of fraction equivalence, addition and subtraction of fractions with like denominators, and multiplication of fractions by whole numbers; (3) and understanding that geometric figures can be analyzed and classified based on their properties, such as having parallel sides, perpendicular sides, particular angle measures, and symmetry. |  |

# Mathematical Rigor

Students reach fluency by building understanding of mathematical concepts – this lays a strong foundation that prepares them for more advanced math work – and by building automaticity in the recall of basic computation facts, such as addition, subtraction, multiplication, and division. As students apply their mathematical knowledge and skills to solve real-world problems, they also gain an understanding of the importance of mathematics throughout their lives. To achieve mathematical understanding, students should be actively engaged in meaningful mathematics. The content and practice standards focus on developing students in the following areas:

* Conceptual understanding – make sense of the math, reason about and understand math concepts and ideas
* Procedural fluency – know mathematical facts, compute and do the math
* Capacity – solve a wide range of problems in various contexts by reasoning, thinking, and applying the mathematics they have learned.

Educators should have the content knowledge to support PK-12 students in achieving this mathematical understanding.

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| **Instructions:** Initial licensure program candidates must reach a level of fluent content knowledge to be endorsed. They must be able to apply content in a range of contexts and vertically connect content to build students’ knowledge. As such, sponsoring organizations must have at least one course at the fluent level for Mathematical Rigor.    Please list the numbers/abbreviations/titles of the **required course(s) where the elements of Mathematical Rigor are explicitly targeted and coherently addressed**. Course identifiers should match the numbers/abbreviations/titles of submitted syllabi.    Then, **briefly describe how course(s) teach candidates to understand content and practice standards using the elements of Mathematical Rigor**. |

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| **Mathematical Rigor** | **Fluent**  *Initial*  *Licensure* |
| *Example Row* | *EDU 101 – Weeks 5-7* |
| * Conceptual understanding – make sense of the math, reason about and understand math concepts and ideas * Procedural fluency – know mathematical facts, compute and do the math * Capacity – solve a wide range of problems in various contexts by reasoning, thinking, and applying the mathematics they have learned. |  |
| *Description:* | |

# Standards for Mathematical Practice

The Standards for Mathematical Practice describe skills that mathematics educators at all levels should seek to develop in their PK-12 students. They complement the content standards so that students increasingly engage with the subject matter as they grow in mathematical maturity and expertise throughout the elementary, middle, and high school years.

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| **Instructions*:***Initial licensure program candidates must reach a level of fluent content knowledge in order to be endorsed. They must be able to apply content in a range of contexts and vertically connect content to build students’ knowledge. As such, sponsoring organizations must have at least one course covering the practices at the fluent level.    Please list the numbers/abbreviations/titles of the **required courses where practices are explicitly targeted and coherently addressed**. Then, **briefly describe where in the syllabus each practice is covered** (i.e., unit name, week number, objective number). Course identifiers should match those of submitted syllabi and practices should not be spread across too many courses. |

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| **Standards for Mathematical Practice** | **Fluent**  *Initial*  *Licensure* |
| *Example Row* | *EDU 101 – Weeks 5-7* |
| **1. Make sense of problems and persevere in solving them.** Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems and try special cases and simpler forms of the original problem to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Older students might, depending on the context of the problem, transform algebraic expressions or change the viewing window on their graphing calculator to get the information they need. Mathematically proficient students can explain correspondences between equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends. Younger students might rely on using concrete objects or pictures to help conceptualize and solve a problem. Mathematically proficient students check their answers to problems using a different method, and they continually ask themselves, “Does this make sense?” They can understand others’ approaches to solving complex problems and identify correspondences among different approaches. |  |
| **2. Reason abstractly and quantitatively.** Mathematically proficient students make sense of the quantities and their relationships in problem situations. Students bring two complementary abilities to bear on problems involving quantitative relationships: the ability to decontextualize—to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to contextualize, to pause as needed during the manipulation process to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meanings of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects. |  |
| **3. Construct viable arguments and critique the reasoning of others.** Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They can analyze situations by breaking them into cases and can recognize and use counterexamples. They justify their conclusions, communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is. Elementary students can construct arguments using concrete referents such as objects, drawings, diagrams, and actions. Such arguments can make sense and be correct, even though they are not generalized or made formal until later grades. Later, students learn to determine domains to which an argument applies. Students at all grades can listen or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments. |  |
| **4. Model with mathematics.** Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They can identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose. |  |
| **5. Use appropriate tools strategically.** Mathematically proficient students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. Proficient students are sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. For example, mathematically proficient high school students analyze graphs of functions and solutions generated using a graphing calculator. They detect possible errors by strategically using estimation and other mathematical knowledge. When making mathematical models, they know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data. Mathematically proficient students at various grade levels can identify relevant external mathematical resources, such as digital content located on a website, and use them to pose or solve problems. They can use technological tools to explore and deepen their understanding of concepts. |  |
| **6. Attend to precision.** Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in communicating their own reasoning verbally and/or in writing. In problem solving they state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. They are careful about specifying units of measure and labeling axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently, expressing numerical answers with a degree of precision appropriate for the problem context. In the elementary grades, students give carefully formulated explanations to each other. By the time they reach high school, they have learned to examine claims and make explicit use of definitions. |  |
| **7. Look for and make use of structure.** Mathematically proficient students look closely to discern a pattern or structure. Young students, for example, might notice that three and seven more is the same amount as seven and three more, or they may sort a collection of shapes according to how many sides the shapes have. Later, students will see 7 x 8 equals the well-remembered 7 x 5 + 7 x 3, in preparation for learning about the distributive property. In the expression x 2 + 9x + 14, older students can see the 14 as 2 x 7 and the 9 as 2 + 7. They recognize the significance of an existing line in a geometric figure and can use the strategy of drawing an auxiliary line for solving problems. They also can step back for an overview and shift perspective. They can see complicated things, such as some algebraic expressions, as single objects or as being composed of several objects. For example, they can see 5 – 3(x – y) 2 as 5 minus a positive number times a square, and use that to realize that its value cannot be more than 5 for any real numbers x and y. |  |
| **8. Look for and express regularity in repeated reasoning.** Mathematically proficient students notice if calculations are repeated and look both for general methods and for shortcuts. Upper elementary students might notice when dividing 25 by 11 that they are repeating the same calculations over and over again, and conclude they have a repeating decimal. By paying attention to the calculation of slope as they repeatedly check whether points are on the line through (1, 2) with slope 3, middle school students might abstract the equation (y – 2)∕(x – 1) = 3. Noticing the regularity in the way terms cancel when expanding (x – 1)(x + 1), (x – 1)(x 2 + x + 1), and (x – 1)(x 3 + x 2 + x + 1) might lead them to the general formula for the sum of a geometric series. As they work to solve a problem, mathematically proficient students maintain oversight of the process, while attending to the details. They continually evaluate the reasonableness of their intermediate results. |  |

# Science and Technology/Engineering Content Progression

The Science and Technology/Engineering Framework includes the following domains of science: Earth and Space, Life, Physical and Technology/Engineering. All domains of science should be addressed in PK through grade 8.At the high school level, courses may specialize in one or more domains. To view this progression, see [Appendix III of the Science and Technology/Engineering Curriculum Framework](https://www.doe.mass.edu/frameworks/scitech/2016-04.pdf#page=134).

To create a strong vertical progression of learning, educators should have the content knowledge to support PK-12 students in mastering prerequisite and advanced standards. Teachers need to be able to access knowledge from prior grades, and teachers who are aware of later content can make better choices about what to emphasize, what language to use, and what larger contexts to provide for their students. This expectation allows teachers to meet students where they are and prepare them for where they are going.

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| **Instructions*:*** The content knowledge below must either be covered directly through program coursework or screened during the admissions process. For each grade level, list the numbers/abbreviations/titles of the **sponsoring organization’s required courses where the content knowledge is explicitly targeted and coherently addressed**. Then, **briefly describe where in the syllabus the content is covered** (i.e., unit name, week number, objective number). Course identifiers should match those of submitted syllabi and content knowledge for each grade level should not be spread across too many courses.    Please note that the full [Science and Technology/Engineering Curriculum Framework](https://www.doe.mass.edu/frameworks/current.html), including the Guiding Principles which are also available in Appendix A of this document, should be consulted when designing programs to ensure appropriate content coverage and rigor for each licensure field’s grade span. Sponsoring organizations should prioritize content fluency in the grade span for the license while ensuring functional content knowledge in the two grade levels below and above the grade span.  To view this progression by grade span, see [Appendix III of the Science and Technology/Engineering Curriculum Framework](https://www.doe.mass.edu/frameworks/scitech/2016-04.pdf#page=134). |

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| **Science and Technology/Engineering Content Progression** | **Course(s) or Screening** |
| *Example Row* | *EDU 101 – Weeks 5-7* |
| **Pre-kindergarten:** Students focus on experiencing and making observations of the world around them. Pre-K students build awareness of the wide variety of natural phenomena and processes in the world around them.   * Earth and Space Science: They are beginning to learn about their own environment as they observe plants and animals, the Moon and the Sun, and the daily weather. * Life Science: They experience their world through their senses and body parts and begin to recognize that animals also use their senses and body parts to meet their basic needs. * Physical Science: They investigate pitch and volume, shadow and light, liquids and solids, and how things move. They sort materials by simple observable properties such as texture and color. They share their understanding of these concepts through discussion as they develop their language and quantitative skills. |  |
| **Kindergarten:** Students build on early experiences observing the world around them as they continue to make observations that are more quantitative in nature and help them identify why some changes occur. Students begin to learn to use these observations as evidence to support a claim through growing language skills.   * Earth and Space Science: Students build their quantitative knowledge of temperature in relation to the weather and its effect on different kinds of materials. They observe that the amount of sunlight shining on a surface causes a temperature change and they design a structure to reduce the warming effects of sunlight. * Life Science: They learn that all animals and plants need food, water, and air to grow and thrive and that the fundamental difference between plants and animals is a plant’s ability to make its own food. * Physical Science: They investigate motions of objects by changing the strength and direction of pushes and pulls. They provide examples of plants and animals that can change their environment through their interactions with it. In kindergarten science, students begin to identify reasons for changes in some common phenomena. |  |
| **Grade 1:** students have more fluency with language, number sense, and inquiry skills. Grade 1 students begin to understand the power of patterns to predict future events in the natural and designed world.   * Earth and Space Science: students describe patterns of motion between the Sun, Moon, and stars in relation to the Earth. From this understanding they can identify seasonal patterns from sunrise and sunset data that will allow them to predict future patterns. Building from their experiences in pre-K and kindergarten observing and describing daily weather, they can now examine seasonal data on temperature and rainfall to describe patterns over time. * Life Science: Students compare the ways different animals and plants use their body parts and senses to do the things they need to do to grow and survive, including typical ways parents keep their young safe so they will survive to adulthood. They notice that though there are differences between plants or animals of the same type, the similarities of behavior and appearance are what allow us to identify them as belonging to a group. * Physical Science: students investigate sound and light through various materials. They describe patterns in how light passes through and sounds differ from different types of materials and use this to design and build a device to send a signal. * Technology/Engineering: Students begin to think about how different solutions can be designed to solve problems. They design, and re-design, possible solutions. |  |
| **Grade 2:** As students grow in their ability to speak, read, write, and reason mathematically, they also grow in their ability to grapple with larger systems and the parts that make them up.   * Earth and Space Science: They learn that water is found everywhere on Earth and takes different forms and shapes. They map landforms and bodies of water and observe that flowing water and wind shapes these landforms. * Life Science: Students start to look beyond the structures of individual plants and animals to looking at the environment in which the plants and animals live as a provider of the food, water, and shelter that the organisms need. * Physical Science: Students use their observation skills gained in earlier grades to classify materials based on similar properties and functions. They construct large objects from smaller pieces and, conversely, learn that when materials are cut into the smallest possible pieces, they still exist as the same material that has weight. These investigations of how parts relate to the whole provide a key basis for understanding systems in later grades. * Technology/Engineering: Students gain experience testing different materials, objects, and designs to collect and then analyze data for the purpose of determining which option is the best for a specific function. |  |
| **Grade 3:** Students develop and sharpen their skills at obtaining, recording and charting, and analyzing data in order to study their environment. They use these practices to study the interactions between humans and earth systems, humans and the environment, and humans and the designed world. They learn that these entities not only interact but influence behaviors, reactions, and traits of organisms. Students reason and provide evidence to support arguments for the influence of humans on nature and nature on human experience.   * Earth and Space Science: students analyze weather patterns and consider humans’ influence and opportunity to impact weather-related events. * Life Science: they study the interactions between and influence of the environment and human traits and characteristics. * Physical Science: Students consider the interactions and consequent reactions between objects and forces, including forces that are balanced or not. * Technology/Engineering: They use the engineering design process to identify a problem and design solutions that enhance humans’ interactions with their surroundings and to meet their needs. |  |
| **Grade 4:** Students observe and interpret patterns related to the transfer of matter and energy on Earth, in physical interactions, and in organisms. Each domain relates to the use of matter and energy over time and for specific purposes.   * Earth and Space Science: students interpret patterns of change over time as related to the deposition and erosion in landscape formation. They study today’s landscapes to provide evidence for past processes. * Life Science: students learn that animals’ internal and external structures support life, growth, behavior, and reproduction. * Physical Science: Students learn about energy—its motion, transfer, and conversion—in different physical contexts. * Technology/Engineering: They work through the engineering design process, focusing on developing solutions by building, testing, and redesigning prototypes to fit a specific purpose. |  |

# Science and Technology/Engineering Practices

The Science and Engineering Practices describe the skills that science educators at all levels should seek to develop in their PK-12 students. This represents a shift from the traditional “scientific method”. Scientific inquiry and engineering design are dynamic and complex processes. Each requires engaging in a range of science and engineering practices to analyze and understand the natural and designed world. They are not defined by a linear, step-by-step approach. They are embedded within the content standards so that as students increasingly engage with the subject matter they grow in scientific maturity and expertise throughout the elementary, middle, and high school years. The progression of the practices by grade band is viewable Appendix I of the [Science and Technology/Engineering Curriculum Framework](https://www.doe.mass.edu/frameworks/current.html).

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| **Instructions*:***Initial licensure program candidates must reach a level of fluent content knowledge to be endorsed. They must be able to apply content in a range of contexts and vertically connect content to build students’ knowledge. As such, sponsoring organizations must have at least one course covering the practices at the fluent level.    Please list the numbers/abbreviations/titles of the **required courses where all eight practices are explicitly targeted and coherently addressed**. Then, **briefly describe where in the syllabus the practices are covered** (i.e., unit name, week number, objective number). Course identifiers should match those of submitted syllabi.    Please note that all eight Science and Technology/Engineering practices overlap and **should be covered together** rather than being split across multiple courses. |

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| **Science and Technology/Engineering Practices** | **Fluent**  *Initial*  *Licensure* |
| *Example Row* | *EDU 101 – Weeks 5-7* |
| The National Research Council’s *Framework for K-12 Science Education* identifies eight essential science and engineering practices that outline the skills necessary to engage in scientific inquiry and engineering design. These practices are core to the [Science and Technology/Engineering Curriculum Framework](https://www.doe.mass.edu/frameworks/current.html).    It is necessary to teach all of these practices embedded with content, so students develop an understanding and facility with the practices in appropriate contexts.   * Students in grades K-12 should engage in all eight practices over each grade band. * Practices grow in complexity and sophistication across the grades. * The eight practices are not separate; they intentionally overlap and interconnect.     1. Asking questions (for science) and defining problems (for engineering)   * Asking questions and defining problems in PK-5 builds on prior experiences and progresses to simple descriptive questions that can be tested and to specifying qualitative relationships. * Asking questions and defining problems in 6-12 progresses to specifying relationships between variables, clarifying arguments and models, and evaluating empirically testable questions and design problems using models and simulations.     2. Developing and using models.   * Modeling in PK-5 builds on prior experiences and progresses to using, developing, and revising simple models (e.g., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. * Modeling in 6-12 builds on PK-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems, and to show relationships among variables between systems and their components in the natural and designed worlds.     3. Planning and carrying out investigations.   * Planning and carrying out investigations to answer questions or test solutions to problems in PK-5 builds on prior experiences and progresses to simple investigations that control variables, which provide data & evidence to support explanations or design solutions. * Planning and carrying out investigations in 6-12 builds on pre-K-5 experiences and progresses to include investigations that use multiple variables and provide evidence for and test conceptual, mathematical, physical, and empirical models.     4. Analyzing and interpreting data.   * Analyzing data in PK-5 builds on prior experiences and collecting, recording, and sharing observations, and progresses to introducing quantitative approaches to collecting data and conducting multiple trials. When possible and feasible, digital tools should be used. * Analyzing data in 6-12 builds on PK-5 experiences and includes quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. It progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.     5. Using mathematics and computational thinking.   * Mathematical and computational thinking in PK-5 builds on prior experience and recognizing that mathematics can be used to describe the natural and designed worlds and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions. * Mathematical and computational thinking in 6-12 builds on pre-K-5 experiences and includes identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. It progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.     6. Constructing explanations (for science) and designing solutions (for engineering).   * Constructing explanations and designing solutions in PK-5 builds on prior experiences and includes use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. It progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. * Constructing explanations and designing solutions in 6-12 builds on pre-K-5 experiences and includes constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. It progresses to constructing and critiquing explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.     7. Engaging in argument from evidence.   * Engaging in argument from evidence in PK-5 builds on prior experiences and includes comparing ideas and representations about the natural and designed worlds. It progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed worlds. * Engaging in argument from evidence in 6-12 builds on PK-5 experiences and includes constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds. It progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.     8. Obtaining, evaluating, and communicating information.   * Obtaining, evaluating, and communicating information in PK-5 builds on prior experiences and includes observations and texts to communicate new information. It progresses to evaluating the merit and accuracy of ideas and methods. * Obtaining, evaluating, and communicating information in 6-12 builds on PK-5 experiences and progresses to evaluating the validity and reliability of claims, methods, and designs. |  |