

Appendix A

Elementary STEM Education Standards (K-5)

1. Content Knowledge

Effective STEM teachers understand and apply the knowledge of contemporary science, major mathematics principles, engineering, and technology. They interrelate and interpret important concepts, ideas, and applications in all STEM fields.

Effective STEM teachers:

1.a. Understand the major concepts, principles, theories, laws, and interrelationships of their fields of licensure and supporting fields as recommended by the National Science Teachers Association.

1.b. Understand the central concepts of the supporting disciplines and the supporting role of science-specific technology.

1.c. Demonstrate and apply knowledge of major mathematics concepts, algorithms, procedures, applications in varied contexts, and connections within and among mathematical domains (Number and Operations (Base ten and fractions), Algebraic Thinking, Geometry, Measurement and Data) as outlined in the *NCTM CAEP Mathematics Content for Middle Grades* or the *NCTM CAEP Mathematics Content for Elementary Mathematics Specialist, and Common Core State Standards*.

1.d. Become literate in Engineering Design which involves key components such as innovation, creativity, critical thinking, problem solving, system thinking, failure as learning experiences, addressing real world problems with multiple solutions and communicating results.

2. Content Pedagogy

Effective STEM teachers not only apply knowledge of curriculum standards for science, technology, engineering, and mathematics; they also focus on the relationships to student learning within and across these domains. These content areas are seen in relationship to one another holistically, not in isolation. These content areas and pedagogy incorporate research-based learning experiences. Thus, educators will learn how to teach the content to their students.

Effective STEM teachers:

2.a. Apply knowledge of curriculum standards for secondary STEM content and their relationship to student learning within and across all STEM domains.

2.b. Analyze and consider research in planning for and leading students in rich and connected STEM learning experiences.

2.c. Plan lessons and units that incorporate a variety of strategies and inquiry approaches, differentiated instruction for diverse populations, and STEM-specific and instructional technologies in building conceptual understanding and procedural proficiency.

2.d. Employ multiple instructional strategies and STEM-specific technological tools in their teaching to develop each student's understanding and proficiency in STEM areas.

2.e. Consistently use scientific inquiry, engineering design, and critical thinking as foundations for developing this connected knowledge for all students.

2.f. Provide students with opportunities to learn through active engagement, selecting high quality tasks, guiding relevant discussions, identifying key conceptual ideas, identifying and addressing student misconceptions, employing a range of questioning strategies, guiding constructive learning experiences, allowing students to connect what they learn to both theoretical and real-world contexts, providing students with opportunities to communicate about science, technology, engineering and mathematics and their relationships, and make connections among these domains, other content areas, everyday life, and the workplace.

2.g. Plan, create or select, implement, and interpret formative and summative assessments for monitoring student learning, measuring student understanding, and informing instruction by reflecting on STEM proficiencies essential for all students.

3. Elementary Learning Environments

Effective K-5 STEM teacher exhibit knowledge of K-5 preschool through pre-adolescent learning, development, and behavior. They include culturally relevant perspectives and demonstrate a positive disposition toward the scientific, engineering, technological, and mathematical processes and learning. The environment is rich with instructional tools developmental applicable for this age group that engage and immerse student in active learning and inquiry.

Effective K-5 STEM teachers will:

3.a. Exhibit knowledge of K-5 preschool through pre-adolescent learning, development, and behavior and demonstrate a positive disposition toward the scientific, engineering, technological, and mathematical processes and learning.

3.b. Incorporate knowledge of individual differences and the cultural and language diversity that exists within K-5 classrooms and include culturally relevant perspectives as a means to motivate and engage all students.

3.c. Demonstrate equitable and ethical treatment of and high expectations for all students.

3.d. Develop lesson plans that include active inquiry where students collect and interpret data using applicable mathematical and science-specific technology while making use of: a) scientific processes, b) engineering design processes, and/or c) mathematical practices, in order to support student understanding of relationships and natural patterns from empirical experiences.

3.e. Apply the engineering design process and science/mathematical content and pedagogical knowledge to select and use instructional tools such as manipulatives, digital tools, and virtual resources to enhance learning while recognizing the possible limitations of such tools.

4. Practices

Effective STEM teachers constantly analyze, evaluate, and strengthen their teaching practice. They are reflective and examine their practices systematically. They employ scientific, engineering, technological, and mathematical practices and develop authentic, inquiry-based scientific, engineering, technological, and mathematical processes.

Effective STEM teachers view all STEM practices as seamless integrations, understanding the connections between the fields of study and recognizing how each of these fields support and strengthen each of the others. Teachers provide evidence that their students are actively engaged in constructive learning through the STEM practices. The practices are to be used comprehensively across all grade levels and are intended to be enacted inclusively, to meet the needs of all students.

Effective STEM teachers develop these practices in their students as “habits of thinking.”

Science	Engineering	Technology	Mathematics
Ask questions	Define problems	Become aware of the web of technological systems on which society depends	Make sense of problems and persevere in solving them
Develop and use models	Develop and use models		Model with mathematics
Plan and carry out investigations	Plan and carry out investigations	Learn how to use new technologies as they become available	Use appropriate tools strategically
Analyze and interpret data	Analyze and interpret data		Attend to precision
Use mathematics and computational thinking	Analyze and interpret data	Recognize the role that technology plays in the advancement of science and engineering	Reason abstractly and quantitatively
Construct explanations	Design solutions		Look for and make use of structure
Engage in argument from evidence	Engage in argument from evidence	Make informed decisions about technology, given its relationship to society and the environment	Construct viable arguments and critique the reasoning of others
Obtain, evaluate, and communicate information	Obtain, evaluate, and communicate information		Look for and express regularity in repeated reasoning

5. Safety

Effective STEM teachers demonstrate and maintain chemical safety, safety procedures, and the ethical treatment of living organisms needed in the STEM environment.

Effective STEM teachers design activities in a classroom that demonstrate:

- 5.a. The safe and proper techniques for the preparation, storage, dispensing, supervision, and disposal of all materials used within their instruction.
- 5.b. An ability to implement emergency procedures and the maintenance of safety equipment, policies and procedures that comply with established state and/or national guidelines, ensuring safe STEM activities appropriate for the abilities of all students.
- 5.c. Ethical decision-making with respect to the treatment of all living organisms in and out of the classroom. They emphasize safe, humane, and ethical treatment of animals and comply with the legal restrictions on the collection, keeping, and use of living organisms.

6. Impact on Student Learning

Effective STEM K-5 teachers provide evidence demonstrating that as a result of their instruction, elementary students' conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and application of integrated STEM concepts in varied contexts have increased. Candidates provide evidence for the diversity of students they teach and that new student knowledge has been created as a consequence of their ability to engage students in a variety of developmentally appropriate STEM activities.

Effective K-5 STEM teachers will:

- 6.a.. Verify that STEM teachers demonstrate conceptual understanding; procedural fluency; the ability to formulate, represent, and solve problems; logical reasoning and continuous reflection on that reasoning; productive disposition toward science, technology, engineer and mathematic and the application of STEM in a variety of contexts.
- 6.b. Engage students in developmentally appropriate STEM inquiries that require active engagement an immerse students in the engineering process while building new knowledge.

6.c. Collect, organize, analyze, and reflect on diagnostic, formative, and summative assessment evidence and determine the extent to which students' engineering, technological, mathematical proficiencies and scientific knowledge have increased and/or corrected.

7. Professional Knowledge and Skills

Effective STEM teachers are lifelong learners and recognize that learning is often collaborative. In their roles as teachers, teacher leaders, and/or coaches/mentors, they participate in and lead STEM-focused professional development experiences at the school and/or district level; draw upon mathematics, science, and STEM education research to inform their practice and the practice of colleagues; continuously reflect on their practice; collaborate with colleagues in using resources from professional content area organizations; and demonstrate STEM-focused instructional leadership.

Effective STEM teachers continuously strive to improve their knowledge and understanding of the ever-changing knowledge base of both content and pedagogy, including approaches for addressing inequities and inclusion for all students in STEM-related fields. They identify with and conduct themselves as part of the math and science education communities.

Effective STEM teachers:

7.a. Serve as both mathematics and science content specialists.

7.b. Take an active role in their professional growth by participating in and leading professional development experiences that directly relate to the learning and teaching of STEM. They engage in continuous and collaborative learning that draws upon research in education to inform practice; enhance learning opportunities for all students' mathematical and scientific knowledge development; involve colleagues, other school professionals, families, and various stakeholders; and advance their development as reflective practitioners.

7.c. Plan, develop, implement, and evaluate STEM-focused professional development programs at the school and/or district levels; use and assist teachers in using resources from professional education organizations such as teacher/leader discussion groups, teacher networks, and print, digital, and virtual resources/collections; and support teachers in systematically reflecting on and learning from their practice.

7.d. Utilize resources from professional mathematics, science, or STEM education organizations such as print, digital, and virtual resources/collections.

7.e. Demonstrate STEM-focused instructional leadership through actions such as coaching/mentoring; building and navigating relationships with teachers, administrators, and the community; establishing and maintaining learning communities; analyzing and evaluating educational structures and policies that affect students' equitable access to high quality STEM instruction; leading efforts to assure that all students have opportunities to learn important STEM topics; evaluating the alignment of STEM curriculum standards, textbooks, and required assessments and making recommendations for addressing learning and achievement gaps; developing appropriate classroom or school-level learning environments; and collaborating with school-based professionals to develop evidence-based interventions for high and low-achieving students.

8. Systematic / Reflective Thinking

Accomplished STEM teachers continually reflect on their teaching practice in order to maximize their own professional growth and improve the quality of their students' learning experiences.

Effective STEM teachers:

8.a. Reflect to ensure that curriculum, instruction, and assessment have been used fairly and equitably for all students.

8.b. Reflect to ensure that students were able to learn the teacher's objectives and their roles in the learning process.

8.c. Reflect daily, yearly and continually throughout their teaching careers.

8.d. Spend time personally reflecting on practices and collaborate with others to aid in reflection process.

8.e. Gather evidence such as notes, videos, students' work, observations from colleagues, photos, and/or curricular materials to aid in the reflection process.

9. Facilitator and Designer of Technology Applications in Education

Effective STEM teachers will create learning opportunities that utilize technology to challenge themselves and all of their students to use the design process to solve problems and foster an environment where all students take ownership of their learning goals and outcomes in all settings. Educators explore and design authentic learning activities that align with content area standards and use technology to create and personalize learning experiences that foster independent learning.

Effective STEM teachers:

- 9.a. Advocate for equitable access to educational technology, digital content, and learning opportunities to meet the diverse needs of all students.
- 9.b. Shape, advance, and accelerate a shared vision for empowered learning with technology by engaging with education stakeholders.
- 9.c. Use technology to create, adapt, and personalize learning experiences that foster independent learning and accommodate learners' differences and needs.
- 9.d. Design authentic learning activities that align with content area standards and use digital tools and resources to maximize active, deep learning.
- 9.e. Explore and apply instructional design principles to create innovative digital learning environments that engage and support learning.

10. Educational Research

Effective STEM teachers conduct teacher-based inquiry research studies by:

- 10.a. Conducting a thorough literature review on a STEM topic.
- 10.b. Developing researchable questions that will generate knowledge for the educational community.
- 10.c. Conducting a study around those questions, including collecting and analyzing data.
- 10.d. Presenting their findings.
- 10.e. Reflecting on the impacts of this research on their practice and modifying instruction as needed.

Appendix B

Secondary STEM Education Standards (6-12)

1. Content Knowledge

Effective STEM teachers understand and apply the knowledge of contemporary science, major mathematics principles, engineering, and technology. They interrelate and interpret important concepts, ideas, and applications in all STEM fields.

Effective STEM teachers:

1.a. Understand the major concepts, principles, theories, laws, and interrelationships of their fields of licensure and supporting fields as recommended by the National Science Teachers Association.

1.b. Demonstrate and apply knowledge of major mathematics concepts, algorithms, procedures, applications in varied contexts, and connections within and among mathematical domains (Number and Operations, Algebra, Geometry and Measurement, Trigonometry, Statistics, Probability, and Calculus) as outlined in the *NCTM CAEP Mathematics Content for Middle Grades* or the *NCTM CAEP Mathematics Content for Elementary Mathematics Specialist*.

1.c. Become literate in the Engineering Design, which involves key components such as innovation, creativity, critical thinking, problem solving, system thinking, failure as learning experiences, addressing real world problems with multiple solutions and communicating results.

1.d. Understand the central concepts of the supporting disciplines and the supporting role of technology.

2. Content Pedagogy

Effective STEM teachers not only apply knowledge of curriculum standards for science, technology, engineering, and mathematics; they also focus on the relationships to student learning within and across these domains. These content areas are seen in relationship to one another holistically, not in isolation. These content areas and pedagogy incorporate research-based learning experiences. Thus, educators will learn how to teach the content to their students.

Effective STEM teachers:

- 2.a. Apply knowledge of curriculum standards for secondary STEM content and their relationship to student learning within and across all STEM domains.
- 2.b. Analyze and consider research in planning for and leading students in rich and connected STEM learning experiences.
- 2.c. Plan lessons and units that incorporate a variety of strategies and inquiry approaches, differentiated instruction for diverse populations, and STEM-specific and instructional technologies in building conceptual understanding and procedural proficiency.
- 2.d. Employ multiple instructional strategies and STEM-specific technological tools in their teaching to develop each student's understanding and proficiency in STEM areas.
- 2.e. Consistently use scientific inquiry, engineering design, and critical thinking as foundations for developing this connected knowledge for all students.
- 2.f. Provide students with opportunities to learn through active engagement, selecting high quality tasks, guiding relevant discussions, identifying key conceptual ideas, identifying and addressing student misconceptions, employing a range of questioning strategies, guiding constructive learning experiences, allowing students to connect what they learn to both theoretical and real-world contexts, providing students with opportunities to communicate about science, technology, engineering and mathematics and their relationships, and make connections among these domains, other content areas, everyday life, and the workplace.
- 2.g. Plan, create or select, implement, and interpret formative and summative assessments for monitoring student learning, measuring student understanding, and informing instruction by reflecting on STEM proficiencies essential for all students.

3. Secondary Education Learning Environments

Effective STEM teachers exhibit knowledge of learning, development, and behavior. They include culturally relevant perspectives and demonstrate a positive disposition toward the scientific, engineering, technological, and mathematical processes and learning. The environment is rich with instructional tools that engage and immerse students in active learning and inquiry.

Effective STEM teachers:

- 3.a. Demonstrate a positive disposition toward the scientific, engineering, technological, and mathematical processes and learning.
- 3.b. Incorporate knowledge of individual differences and the cultural and language diversity that exists within classrooms and include culturally relevant perspectives as a means to motivate and engage all students.
- 3.c. Demonstrate equitable and ethical treatment of and high expectations for all students.
- 3.d. Design a learning environment that promotes active inquiry where students collect and interpret data using applicable mathematical and science-specific technology while making use of scientific processes, engineering design processes, and/or mathematical practices to support student's understanding of relationships and natural patterns from empirical experiences.
- 3.e. Apply the engineering design process and science/mathematical content and pedagogical knowledge to select and use instructional tools such as manipulatives, digital tools, and virtual resources to enhance learning while recognizing the possible limitations of such tools.

4. Practices

Effective STEM teachers constantly analyze, evaluate, and strengthen their teaching practice. They are reflective and examine their practices systematically. They employ scientific, engineering, technological, and mathematical practices and develop authentic, inquiry-based scientific, engineering, technological, and mathematical processes.

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- 5.c. Ethical decision-making with respect to the treatment of all living organisms in and out of the classroom. They emphasize safe, humane, and ethical treatment of animals and comply with the legal restrictions on the collection, keeping, and use of living organisms.

6. Impact on Student Learning:

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Effective STEM teachers:

- 6.a. Verify their students' development of conceptual understanding; procedural fluency; ability to formulate, represent, and solve problems; logical reasoning and continuous reflection on that reasoning; productive disposition toward science, technology, engineering and mathematics and the application of STEM in a variety of contexts.
- 6.b. Engage students in developmentally appropriate STEM inquiries that require active engagement and immerse students in the engineering process while building new knowledge.

6.c. Collect, organize, analyze, and reflect on diagnostic, formative, and summative assessment evidence and determine the extent to which students' engineering, technological, mathematical proficiencies and scientific knowledge have increased and/or been corrected.

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- 10.b. Developing researchable questions that will generate knowledge for the educational community.
- 10.c. Conducting a study around those questions, including collecting and analyzing data.
- 10.d. Presenting their findings.
- 10.e. Reflecting on the impacts of this research on their practice and modifying instruction as needed.

11. Engineering as a Context for Teaching and Learning

Effective secondary STEM teachers demonstrate the ability to incorporate engineering design into their teaching and use it as a pedagogical approach to encourage contextual, student-centered learning to provide meaningful opportunities for applying mathematical and scientific concepts.

Effective STEM teachers:

- 11.a. Emphasize engineering design in their instruction.
- 11.b. Incorporate important and developmentally appropriate mathematics, science, and technology skills and knowledge in the context of engineering.
- 11.c. Promote engineering habits of mind.

12. Integrated STEM Education in Action

Effective secondary STEM teachers demonstrate the ability to plan and implement integrated STEM lessons. These lessons range from interdisciplinary to multidisciplinary to transdisciplinary.

Effective STEM teachers:

- 12.a. Design rigorous and relevant student-centered lessons that integrate multiple disciplines, are driven by student questions, and are centered on real-life problems or projects. These lessons engage students in applying knowledge and skills from two or more disciplines and in helping to shape their learning experiences.
- 12.b. Develop, implement, and interpret results of assessments of concepts and skills that draw on methods from multiple disciplines and involve students in self-evaluation.