Engineering Design Challenge Planning Guide (Grade 5)

Engineering Design Challenge Planning Guide

STEM professions require individuals to apply their content knowledge to unique circumstances and to solve problems using creativity and innovation. When engineers are presented with a problem, they use language skills when researching to determine if the problem has occurred before and what innovations have been made in the past (historical connection). Then, the engineer will use engineering practices to develop a solution that applies science and math knowledge. Engineering design challenges can be created for a specific standard or aligned with multiple standards and subject areas. Cross-disciplinary instruction introduces concepts and skills that could be linked from two or more disciplines to highlight connections and deepen understanding. Integrated learning can help students see the connection between what they are learning in every class and braid that understanding together to create a solution to a problem using the engineering design process.

Purpose of this Guide:

This guide supports educators in developing cross-curricular engineering design challenges anchored in the science standards. While engineering practices are embedded in the Texas Essential Knowledge and Skills (TEKS) for science, engineering design challenges can draw from multiple subject areas. By integrating content across disciplines, students apply their knowledge in meaningful ways to solve a real-world problem.

This guide provides the following components:

- A graphic organizer to organize targeted standards
- A content crosswalk to help educators identify potential connections for an engineering design challenge
- STEM career highlights for each student expectation
- Stakeholder engagement ideas

Engineering Design Practices:

When developing an engineering design challenge, it is important to anchor the challenge in TEKS. The students will use the engineering practice TEKS paired with the science content TEKS when solving the engineering design challenge. The first strand in the science TEKS outlines the scientific and engineering practices for the grade level/courses. Engineering practices refer to the methods, techniques, and standards that engineers use to ensure their work is efficient, reliable, safe, and meets the intended requirements. To create a cohesive learning experience, educators should integrate scientific and engineering practices with content. Embedding these practices across the content areas as part of engineering design challenges provides students with the context in which to ask questions, develop models, and analyze data that supports critical thinking and problem-solving skills in real-world scenarios.

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Engineering Design Process:

The engineering design process is a systematic way of thinking, used to teach and apply concepts and skills in an integrated manner. Students engage with concepts from multiple disciplines while using design thinking to develop a solution to an open-ended, authentic problem. Learning from failure is a natural part of the iterative process. There are numerous engineering design process models; however, they share foundational practices that include identifying questions or defining problems, imagining solutions, brainstorming ideas, planning, creating, testing, and improving a design.

Engineering Related TEKS:

In grade 5 science, the following engineering practices can be paired with engineering design challenges. The student is expected to:

Science.5.1.A ask questions and define problems based on observations or information from text, phenomena, models, or investigations

Science.5.1.B use scientific practices to plan and conduct descriptive and simple experimental investigations and use engineering practices to design solutions to problems

Science.5.1.G develop and use models to represent phenomena, objects, and processes or design a prototype for a solution to a problem

Science.5.2.D evaluate experimental and engineering designs

Science.5.4.A how scientific discoveries and innovative solutions to problems impact science and society

Science.5.4.B research and explore resources such as museums, libraries, professional organizations, private companies, online platforms, and mentors employed in a science, technology, engineering, and mathematics (STEM) field to investigate STEM careers

Science.5.5.A identify and use patterns to describe phenomena or design solutions

Communication is also part of the engineering design process. Claim-Evidence-Reasoning (CER) is a discussion structure commonly used by scientists and engineers to engage in collaborative discussions with peers. While both scientists and engineers use the CER structure, they use it for different purposes. Scientists tend to focus on asking questions and analyzing patterns, while engineers tend to focus on solving problems. The following student expectations demonstrate the knowledge and skills students apply to communicate their thinking. The student is expected to:

Science.5.3.A develop explanations and propose solutions supported by data and models

Science.5.3.B communicate explanations and solutions individually and collaboratively in a variety of settings and formats

Science.5.3.C listen actively to others' explanations to identify relevant evidence and engage respectfully in scientific discussion

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Integration Planning Graphic Organizer Component:

The *Integration Planning Graphic Organizer* can be used in conjunction with the Integrated Content Crosswalk for STEM Education to organize the standards and subject areas incorporated into an engineering design challenge. The graphic organizer serves as a workspace to capture ideas of possible connections, but not all spaces need to be filled. Many factors will influence the selection of standards during an engineering design challenge. For example, instructional materials, district scope and sequences, student age, and other factors that inform instructional decisions.

On the next page is an example of a grade 5 science engineering design challenge developed using the components of this planning guide. In this example, the graphic organizer has been completed with information from the Integrated Content Crosswalk for STEM Education. There are many ways to approach developing an engineering design challenge. An easy way to start is to select your science content standard, then identify the problem that needs to be solved, and what engineering practices will be used when solving the problem. The highlighted standard below is the content standard used as an anchor for this challenge. The engineering practices that align with this challenge are Science.5.1.G and Science.5.4.A.

Highlighted Standards from the Example:

The student is expected to:
Science.5.6.A compare and contrast matter based on measurable, testable, or observable physical properties, including mass, magnetism, relative density (sinking and floating using water as a reference point), physical state (solid, liquid, gas), volume, solubility in water, and the ability to conduct or insulate thermal energy and electric energy
Science.5.1.G develop and use models to represent phenomena, objects, and processes or design a prototype for a solution to a problem
Science.5.4.A how scientific discoveries and innovative solutions to problems impact science and society

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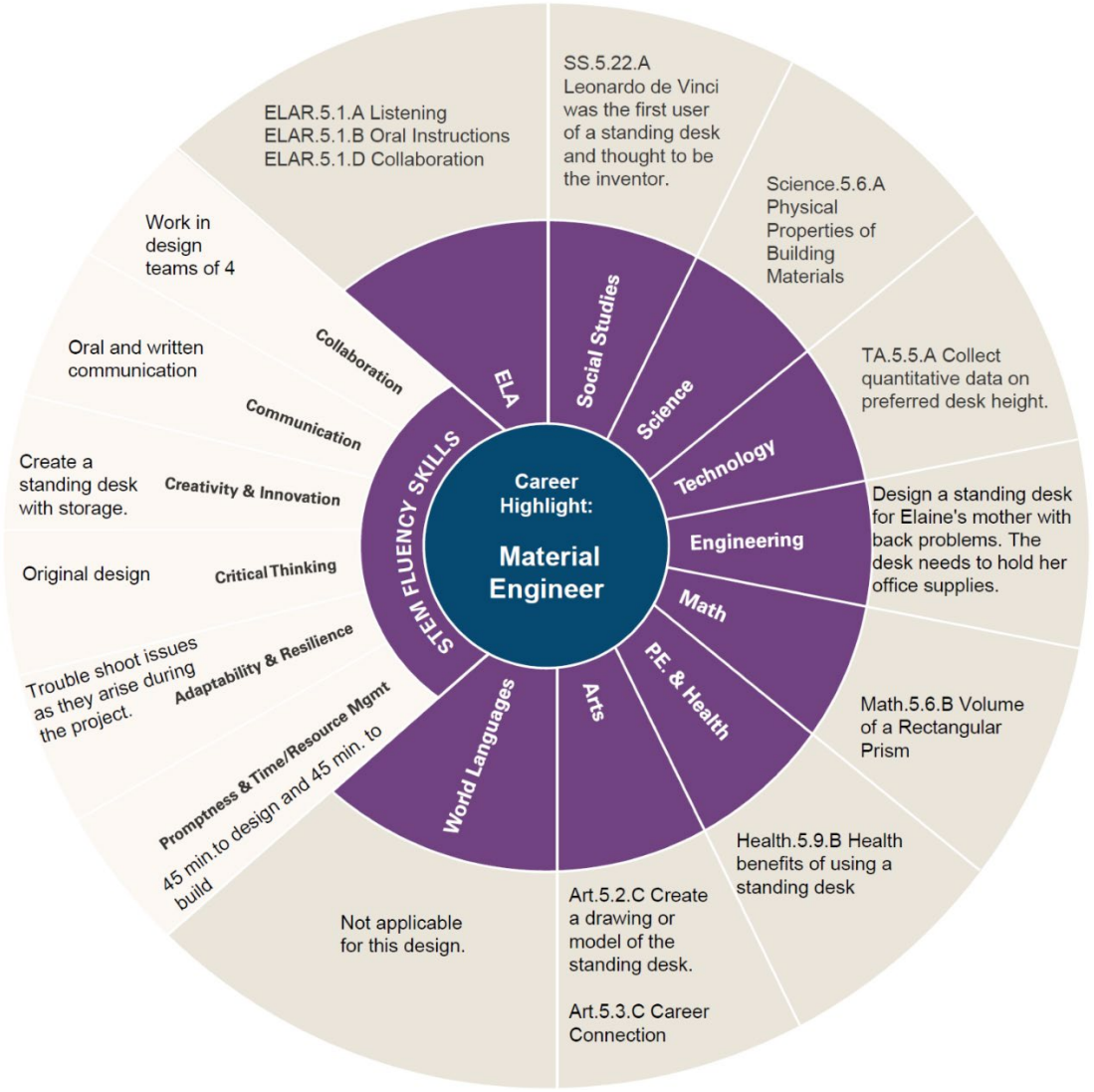

Engineering Design Challenge: Design a standing desk for Elaine's mother with back problems. The desk needs to hold her office supplies.

Core Subject Area Connection Summary:

Science.5.6.A Physical Properties of Building Materials

Math.5.6.B Volume of a Rectangular Prism

SS.5.22.A Leonardo de Vinci was the first user of a standing desk and thought to be the inventor

ELAR.5.1.A Listening, ELAR.5.1.B Oral Instructions, ELAR.5.1.D Collaboration

Enrichment Area Connection Summary:

TA.5.5.A Collect quantitative data on preferred desk height

Health.5.9.B Health benefits of using a standing desk

Art.5.2.C Create a drawing or model of the standing desk

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Integrated Content Crosswalk for STEM Education Component:

The Integrated Content Crosswalk for STEM Education section is a resource designed to help teachers identify connections between student expectations across the required curricula. It is important to note that this tool offers suggestions. Educators may use the suggestions in the crosswalk as a starting place for selecting student expectations across disciplines for an engineering design challenge. Student expectations in an integrated content crosswalk will vary and should align with the design challenge. The Integration Planning Graphic Organizer example provided for grade 5 included the student expectations from the crosswalk, as well as additional standards from health and art. The boxes on the chart excerpt below indicate the student expectations that were used in the previous example on the graphic organizer.

In a STEM career, professionals must communicate throughout a design process. Students will practice language skills during engineering design challenges by using written and oral communication, research, questioning, and synthesizing information. Students may also use technology to create, develop, and communicate their ideas. The standards aligned to each project will change depending on what students are doing in the design challenge.

Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.5.6.A compare and contrast matter based on measurable, testable, or observable physical properties, including mass, magnetism, relative density (sinking and floating using water as a reference point), physical state (solid, liquid, gas), volume, solubility in water, and the ability to conduct or insulate thermal energy and electric energy **Career Highlights:** Materials Engineers, Machinists, Service Unit Operators	**Math.5.1.E** create and use representations to organize, record, and communicate mathematical ideas **Math.5.6.A** recognize a cube with side length of one unit as a unit cube having one cubic unit of volume and the volume of a three-dimensional figure as the number of unit cubes (n cubic units) needed to fill it with no gaps or overlaps if possible **Math.5.6.B** determine the volume of a rectangular prism with whole number side lengths in problems related to the number of layers times the number of unit cubes in the area of the base	**SS.5.22.A** identify the accomplishments of notable individuals in the fields of science and technology such as Benjamin Franklin and Thomas Edison	**ELAR.5.1.B** follow, restate, and give oral instructions that include multiple action steps **ELAR.5.1.D** work collaboratively with others to develop a plan of shared responsibilities **ELAR.5.13.A** generate questions on a topic for formal and informal inquiry	**TA.5.5.A** identify and collect quantitative and qualitative data with digital tools

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Career Highlights Component:

The career highlights section is listed below each science student expectation in the Integrated Content Crosswalk for STEM Education. The career highlights are designed to provide career connections to the science content being taught. On the *Integrated Content Crosswalk*, each science standard has three career connections that support the incorporation of scientific and engineering practices for investigating STEM careers. The careers highlighted use the science content regularly by STEM professionals in their careers. The career highlights link provides a description of the career, education requirements, and wage range of the profession. The Texas Workforce Commission and O*NET provide the labor data information. Connecting engineering design challenges to careers promotes career awareness and provides relevance for learning content.

Getting Started:

To begin developing your own cross-curricular engineering design challenge, start by selecting a science content standard that aligns with your instructional goals. Use the Integration Planning Graphic Organizer in conjunction with the Integrated Content Crosswalk for STEM Education to identify meaningful connections across subject areas and incorporate relevant student expectations. Consider which engineering practices will be used to solve the real-world problem presented in the engineering design challenge. Leverage the career highlights to introduce students to STEM professions and make learning more relevant. As you plan, remember to adapt this tool to fit your students' needs, available resources, and instructional context.

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Integrated Content Crosswalk for STEM Education and Career Highlights Component:

Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.5.6.A compare and contrast matter based on measurable, testable, or observable physical properties, including mass, magnetism, relative density (sinking and floating using water as a reference point), physical state (solid, liquid, gas), volume, solubility in water, and the ability to conduct or insulate thermal energy and electric energy **Career Highlights:** Materials Engineers, Machinists, Service Unit Operators	**Math.5.1.E** create and use representations to organize, record, and communicate mathematical ideas **Math.5.6.A** recognize a cube with side length of one unit as a unit cube having one cubic unit of volume and the volume of a three-dimensional figure as the number of unit cubes (n cubic units) needed to fill it with no gaps or overlaps if possible **Math.5.6.B** determine the volume of a rectangular prism with whole number side lengths in problems related to the number of layers times the number of unit cubes in the area of the base	**SS.5.22.A** identify the accomplishments of notable individuals in the fields of science and technology such as Benjamin Franklin and Thomas Edison	**ELAR.5.1.B** follow, restate, and give oral instructions that include multiple action steps **ELAR.5.1.D** work collaboratively with others to develop a plan of shared responsibilities **ELAR.5.13.A** generate questions on a topic for formal and informal inquiry	**TA.5.5.A** identify and collect quantitative and qualitative data with digital tools
Science.5.6.B demonstrate and explain that some mixtures maintain physical properties of their substances such as iron filings and sand or sand and water **Career Highlights:** Engineers, Registered Nurses - RN, Chemical Plant Operators			**ELAR.5.1.B** follow, restate, and give oral instructions that include multiple action steps **ELAR.5.1.D** work collaboratively with others to develop a plan of shared responsibilities **ELAR.5.13.A** generate questions on a topic for formal and informal inquiry	

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Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.5.6.C compare the properties of substances before and after they are combined into a solution and demonstrate that matter is conserved in solutions **Career Highlights:** Medical Laboratory Technicians, Engineers, Chemical Plant Operators			**ELAR.5.1.B** follow, restate, and give oral instructions that include multiple action steps **ELAR.5.1.D** work collaboratively with others to develop a plan of shared responsibilities **ELAR.5.13.A** generate questions on a topic for formal and informal inquiry	
Science.5.6.D illustrate how matter is made up of particles that are too small to be seen such as air in a balloon **Career Highlights:** HVAC Mechanics, Aerospace Engineers, Chemists			**ELAR.5.13.A** generate questions on a topic for formal and informal inquiry **ELAR.5.13.C** identify and gather relevant information from a variety of sources **ELAR.5.13.E** demonstrate understanding of information gathered	
Science.5.7.A investigate and explain how equal and unequal forces acting on an object cause patterns of motion and transfer of energy **Career Highlights:** Mobile Heavy Equipment Mechanics, Engineers, Aerospace Engineers	**Math.5.1.E** create and use representations to organize, record, and communicate mathematical ideas **Math.5.9.A** represent categorical data with bar graphs or frequency tables and numerical data, including data sets of measurements in fractions or decimals, with dot plots or stem-and-leaf plots **Math.5.9.B** represent discrete paired data on a scatterplot		**ELAR.5.1.B** follow, restate, and give oral instructions that include multiple action steps **ELAR.5.1.D** work collaboratively with others to develop a plan of shared responsibilities	**TA.5.1.B** identify patterns in real-world problems and make predictions based on the pattern **TA.5.5.A** identify and collect quantitative and qualitative data with digital tools **TA.5.6.A** use digital tools to analyze and transform data and make inferences to answer questions

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Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.5.7.B design a simple experimental investigation that tests the effect of force on an object in a system such as a car on a ramp or a balloon rocket on a string **Career Highlights:** Engineers, Physicists, Airline Pilots, Copilots, and Flight Engineers	**Math.5.1.E** create and use representations to organize, record, and communicate mathematical ideas **Math.5.9.A** represent categorical data with bar graphs or frequency tables and numerical data, including data sets of measurements in fractions or decimals, with dot plots or stem-and-leaf plots **Math.5.9.B** represent discrete paired data on a scatterplot	**SS.5.22.A** identify the accomplishments of notable individuals in the fields of science and technology such as Benjamin Franklin, Eli Whitney, John Deere, Thomas Edison, Alexander Graham Bell, George Washington Carver, the Wright Brothers, and Neil Armstrong	**ELAR.5.1.B** follow, restate, and give oral instructions that include multiple action steps **ELAR.5.1.D** work collaboratively with others to develop a plan of shared responsibilities	**TA.5.5.A** identify and collect quantitative and qualitative data with digital tools
Science.5.8.A investigate and describe the transformation of energy in systems such as energy in a flashlight battery that changes from chemical energy to electrical energy to light energy **Career Highlights:** Electrical Engineering Technicians, Electricians, Wind Energy Engineers	**Math.5.1.D** communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate **Math.5.1.E** create and use representations to organize, record, and communicate mathematical ideas **Math.5.1.F** analyze mathematical relationships to connect and communicate mathematical ideas	**SS.5.22.A** identify the accomplishments of notable individuals in the fields of science and technology such as Benjamin Franklin, Eli Whitney, Thomas Edison, and Alexander Graham Bell	**ELAR.5.1.B** follow, restate, and give oral instructions that include multiple action steps **ELAR.5.1.D** work collaboratively with others to develop a plan of shared responsibilities	**TA.5.3.A** explain the importance of and demonstrate personal skills and behaviors, including persistence, effective communication, following directions, mental agility, metacognition, problem solving, and questioning, that are needed to implement a design process successfully

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Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.5.8.B demonstrate that electrical energy in complete circuits can be transformed into motion, light, sound, or thermal energy and identify the requirements for a functioning electrical circuit **Career Highlights:** Electrical Engineering Technicians, Electricians, Signal and Track Switch Repairers			**ELAR.5.1.D** work collaboratively with others to develop a plan of shared responsibilities **ELAR.5.13.B** develop and follow a research plan with adult assistance **ELAR.5.13.E** demonstrate understanding of information gathered	
Science.5.8.C demonstrate and explain how light travels in a straight line and can be reflected, refracted, or absorbed **Career Highlights:** Photonics Engineers, Physicists, Interior Designers			**ELAR.5.1.B** follow, restate, and give oral instructions that include multiple action steps **ELAR.5.1.D** work collaboratively with others to develop a plan of shared responsibilities **ELAR.5.13.B** develop and follow a research plan with adult assistance	
Science.5.9.A demonstrate that Earth rotates on its axis once approximately every 24 hours and explain how that causes the day/night cycle and the appearance of the Sun moving across the sky, resulting in changes in shadow positions and shapes. **Career Highlights:** Astronomers, Aerospace Engineers, Architects			**ELAR.5.6.E** make connections to personal experiences, ideas in other texts, and society **ELAR.5.6.F** make inferences and use evidence to support understanding **ELAR.5.13.A** generate and clarify questions on a topic for formal and informal inquiry	**TA.5.1.B** identify patterns in real-world problems and make predictions based on the pattern

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Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.5.10.A explain how the Sun and the ocean interact in the water cycle and affect weather **Career Highlights:** Atmospheric and Space Scientists, Geoscientists, Hydrologists			**ELAR.5.6.E** make connections to personal experiences, ideas in other texts, and society **ELAR.5.6.F** make inferences and use evidence to support understanding **ELAR.5.13.A** generate and clarify questions on a topic for formal and informal inquiry	
Science.5.10.B model and describe the processes that led to the formation of sedimentary rocks and fossil fuels **Career Highlights:** Geoscientists, Mining & Geological Engineers, Anthropologists & Archeologists			**ELAR.5.13.A** generate questions on a topic for formal and informal inquiry **ELAR.5.13.C** identify and gather relevant information from a variety of sources **ELAR.5.13.E** demonstrate understanding of information gathered	
Science.5.10.C model and identify how changes to Earth's surface by wind, water, or ice result in the formation of landforms, including deltas, canyons, and sand dunes **Career Highlights:** Park Naturalists, Geographers, Geoscientists		**SS.5.6.B** describe regions in the United States based on physical characteristics such as landform, climate, and vegetation	**ELAR.5.13.A** generate questions on a topic for formal and informal inquiry **ELAR.5.13.C** identify and gather relevant information from a variety of sources **ELAR.5.13.E** demonstrate understanding of information gathered	

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Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.5.11.A design and explain solutions such as conservation, recycling, or proper disposal to minimize environmental impact of the use of natural resources. **Career Highlights:** Engineers, Agricultural Engineers, Conservation Scientists	**Math.5.1.G** display, explain, and justify mathematical ideas and arguments using precise mathematical language in written or oral communication **Math.5.9.A** represent categorical data with bar graphs or frequency tables and numerical data, including data sets of measurements in fractions or decimals, with dot plots or stem-and-leaf plots **Math.5.9.B** represent discrete paired data on a scatterplot	**SS.5.8.A** describe how and why people have adapted to and modified their environment in the United States such as the use of human resources to meet basic needs **SS.5.8.A** analyze the positive and negative consequences of human modification of the environment in the United States	**ELAR.5.6.E** make connections to personal experiences, ideas in other texts, and society **ELAR.5.13.A** generate questions on a topic for formal and informal inquiry	
Science.5.12.A observe and describe how a variety of organisms survive by interacting with biotic and abiotic factors in a healthy ecosystem **Career Highlights:** Range Managers, Biologists, Zoologists & Wildlife Biologists	**Math.5.1.A** apply mathematics to problems arising in everyday life, society, and the workplace **Math.5.8.C** graph in the first quadrant of the coordinate plane ordered pairs of numbers arising from mathematical and real-world problems, including those generated by number patterns or found in an input-output table **Math.5.9.A** represent categorical data with bar graphs or frequency tables and numerical data, including data sets of measurements in fractions or decimals, with dot plots or stem-and-leaf plots	**SS.5.8.A** describe how and why people have adapted to and modified their environment in the United States such as the use of human resources to meet basic needs **SS.5.8.B** analyze the positive and negative consequences of human modification of the environment in the United States	**ELAR.5.6.G** evaluate details read to determine key ideas **ELAR.5.13.A** generate questions on a topic for formal and informal inquiry **ELAR.5.13.E** demonstrate understanding of information gathered	

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Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.5.12.B predict how changes in the ecosystem affect the cycling of matter and flow of energy in a food web **Career Highlights:** Soil & Plant Scientists, Biologists, Farmworkers & Laborers, Crop, Nursery, & Greenhouse	**Math.5.8.C** graph in the first quadrant of the coordinate plane ordered pairs of numbers arising from mathematical and real-world problems, including those generated by number patterns or found in an input-output table **Math.5.9.A** represent categorical data with bar graphs or frequency tables and numerical data, including data sets of measurements in fractions or decimals, with dot plots or stem-and-leaf plots		**ELAR.5.7.C** use text evidence to support an appropriate response **ELAR.5.13.A** generate questions on a topic for formal and informal inquiry **ELAR.5.13.E** demonstrate understanding of information gathered	**TA.5.1.B** identify patterns in real-world problems and make predictions based on the pattern
Science.5.12.C describe a healthy ecosystem and how human activities can be beneficial or harmful to an ecosystem **Career Highlights:** Environmental Engineers, Environmental Science and Protection Technicians, Environmental Restoration Planners	**Math.5.8.C** graph in the first quadrant of the coordinate plane ordered pairs of numbers arising from mathematical and real-world problems, including those generated by number patterns or found in an input-output table **Math.5.9.A** represent categorical data with bar graphs or frequency tables and numerical data, including data sets of measurements in fractions or decimals, with dot plots or stem-and-leaf plots	**SS.5.8.A** describe how and why people have adapted to and modified their environment in the United States such as the use of human resources to meet basic needs **SS.5.8.B** analyze the positive and negative consequences of human modification of the environment in the United States	**ELAR.5.7.C** use text evidence to support an appropriate response **ELAR.5.13.A** generate questions on a topic for formal and informal inquiry **ELAR.5.13.E** demonstrate understanding of information gathered	

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Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.5.13.A analyze the structures and functions of different species to identify how organisms survive in the same environment **Career Highlights:** Biologists, Zoologists and Wildlife, Geneticists		**SS.5.8.A** describe how and why people have adapted to and modified their environment in the United States such as the use of human resources to meet basic needs	**ELAR.5.13.A** generate questions on a topic for formal and informal inquiry **ELAR.5.13.C** identify and gather relevant information from a variety of sources **ELAR.5.13.E** demonstrate understanding of information gathered	
Science.5.13.B explain how instinctual behavioral traits such as turtle hatchlings returning to the sea and learned behavioral traits such as orcas hunting in packs increase chances of survival **Career Highlights:** Zoologists and Wildlife Biologists, Biologists, Geneticists		**SS.5.1.B** describe the accomplishments of significant individuals who settled for religious freedom and economic gain during the colonial period, including William Bradford, Anne Hutchinson, William Penn, John Smith, and Roger Williams	**ELAR.5.13.A** generate questions on a topic for formal and informal inquiry **ELAR.5.13.C** identify and gather relevant information from a variety of sources **ELAR.5.13.E** demonstrate understanding of information gathered	

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Stakeholder Engagement Component:

This section highlights the various ways different external stakeholders can utilize the integrated learning crosswalk. The Integrated Content for STEM Education crosswalk can be used in the following ways to:

Parents:

- highlight content alignment across their child's grade level.
- provide context to parents to communicate the relevance of schoolwork to their child.
- explore different careers with their child and learn about various STEM occupations.

K–12 Education:

- provide ideas for connecting learning for students across different subject areas.
- give campuses ideas for how to connect career awareness to content.
- align K–5 career awareness activities with feeder pathways leading to high school career technical education programs of study.
- providing cross-curricular instruction allows students to understand the collaborative nature of STEM careers.

Institutes of Higher Education:

- support pre-service teachers in developing cross-curricular projects without researching all the subject standards.
- provide guidance for professors who are designing cross-curricular projects for courses and professional development.
- offer departments a better understanding of the content students learn before entering higher education programs.

Non-Profit Organizations:

- support the design of cross-curricular programs, curricula, and professional development aligned with state standards for in and out-of-school time.
- use the crosswalk to align current programming with standards from different subject areas and provide a uniform way to measure student outcomes in programs.
- provide self-contained teachers with cross-curricular lessons during professional development.

Business and Industry:

- connect engineering design challenges to local businesses to get professional design feedback.
- find industry mentors for teachers and students on content and designs.
- connect schools with industry to offer "lunch and learns" with industry workers, guest speakers, and externships or professional development for teachers aligned with their lesson's career focus.