Engineering Design Challenge Planning Guide (Kindergarten)

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. Engineering practices are part of the student expectations in the Texas Essential Knowledge and Skills (TEKS) for science. However, an engineering design challenge can incorporate content from multiple subject areas to enable students to apply content 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 kindergarten science, the following standards include engineering practices and could be paired with engineering design challenges. The student is expected to:

- Science.K.1.A ask questions and define problems based on observations or information from text, phenomena, models, or investigations
- Science.K.1.B use scientific practices to plan and conduct simple descriptive investigations and use engineering practices to design solutions to problems
- Science.K.1.G develop and use models to represent phenomena, objects, and processes or design a prototype for a solution to a problem
- Science.K.2.D evaluate a design or object using criteria to determine if it works as intended
- Science.K.4.A explain how science or an innovation can help others
- Science.K.4.B identify scientists and engineers such as Isaac Newton, Mae Jemison, and Ynes Mexia and explore what different scientists and engineers do
- Science.K.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.K.3.A develop explanations and propose solutions supported by data and models
- Science.K.3.B communicate explanations and solutions individually and collaboratively in a variety of settings and formats
- Science.K.3.C listen actively to others' explanations to identify important 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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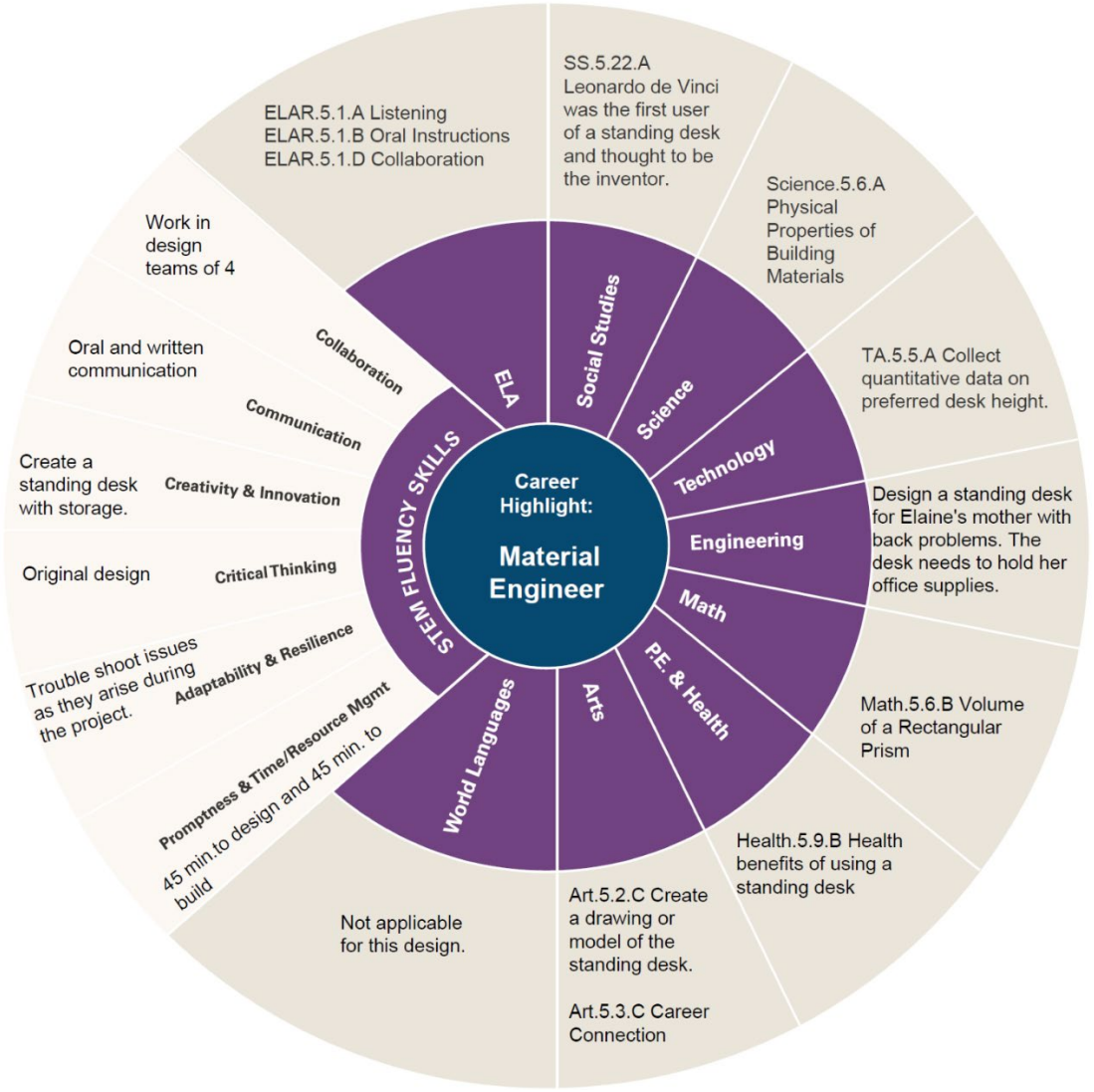

Engineering Design Challenge: Design a standing desk for Elaine's mother with back problems. The desk needs to hold her office supplies.

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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Texas Education Agency

Integrated Content Crosswalk for STEM Education and Career Highlights:

Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.K.6.A identify and record observable physical properties of objects, including shape, color, texture, and material, and generate ways to classify objects **Career Highlights:** Materials Engineers, Machinists, Service Unit Operators	**Math.K.6.D** identify attributes of two-dimensional shapes using informal and formal geometric language interchangeably **Math.K.6.E** classify and sort a variety of regular and irregular two- and three-dimensional figures regardless of orientation or size **Math.K.7.A** give an example of a measurable attribute of a given object including length, capacity, and weight			**TA.K.1.B** identify simple patterns and make predictions based on the patterns **TA.K.4.A** communicate an understanding that data is information collected about people, events, or objects such as computer searches and weather patterns
Science.K.7.A describe and predict how a magnet interacts with various materials and how magnets can be used to push or pull **Career Highlights:** Non-destructive Testing Specialists, Magnetic Resonance Imaging Technologists, Mining and Geological Engineers				**TA.K.1.B** identify simple patterns and make predictions based on the patterns

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Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.K.8.A communicate the idea that objects can only be seen when a light source is present and compare the effects of different amounts of light on the appearance of objects **Career Highlights:** Photonics Engineers, Physicists, Interior Designers,	**Math.K.1.D** communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate **Math.K.7.B** compare two objects with a common measurable attribute to see which object has more of/less of the attribute and describe the difference		**ELAR.K.1.C** share information and ideas by speaking audibly and clearly using the conventions of language	
Science.K.8.B demonstrate and explain that light travels through some objects and is blocked by other objects, creating shadows **Career Highlights:** Physicists, Interior Designers, Architects			**ELAR.K.1.C** share information and ideas by speaking audibly and clearly using the conventions of language **ELAR.K.12.D** demonstrate understanding of information gathered with adult assistance	
Science.K.9.A identify, describe, and predict the patterns of day and night and their observable characteristics **Career Highlights:** Atmospheric and Space Scientists, Geoscientists, Astronomers			**ELAR.K.12.C** gather information from a variety of sources with adult assistance	**TA.K.1.B** identify simple patterns and make predictions based on the patterns

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Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.K.9.B observe, describe, and illustrate the Sun, Moon, stars, and objects in the sky such as clouds **Career Highlights:** Atmospheric and Space Scientists, Geoscientists, Hydrologists			**ELAR.K.1.C** share information and ideas by speaking audibly and clearly using the conventions of language **ELAR.K.12.C** gather information from a variety of sources with adult assistance **ELAR.K.12.E** use an appropriate mode of delivery, whether written, oral, or multimodal, to present results	**TA.K.4.A** communicate an understanding that data is information collected about people, events, or objects such as computer searches and weather patterns
Science.K.10.A describe and classify rocks by the observable properties of size, shape, color, and texture **Career Highlights:** Geographers, Geoscientists, Soil & Plant Scientists			**ELAR.K.12.E** use an appropriate mode of delivery, whether written, oral, or multimodal, to present results	**TA.K.4.A** communicate an understanding that data is information collected about people, events, or objects such as computer searches and weather patterns
Science.K.10.B observe and describe weather changes from day to day and over seasons **Career Highlights:** Atmospheric and Space Scientists, Geoscientists, Hydrologists		**SS.K.4.A** identify the physical characteristics of place such as landforms, bodies of water, Earth's resources, and weather	**ELAR.K.6.B** provide an oral, pictorial, or written response to a text **ELAR.K.12.E** use an appropriate mode of delivery, whether written, oral, or multimodal, to present results	**TA.K.4.A** communicate an understanding that data is information collected about people, events, or objects such as computer searches and weather patterns

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Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.K.10.C identify evidence that supports the idea that air is all around us and demonstrate that wind is moving air using items such as a windsock, pinwheel, or ribbon **Career Highlights:** Atmospheric and Space Scientists, Wind Energy Engineers, Wind Turbine Service Technicians			**ELAR.K.6.A** describe personal connections to a variety of sources	**TA.K.4.A** communicate an understanding that data is information collected about people, events, or objects such as computer searches and weather patterns
Science.K.11.A observe and generate examples of practical uses for rocks, soil, and water **Career Highlights:** Geoscientists, Anthropologists & Archeologists, Soil & Plant Scientists		**SS.K.4.A** identify the physical characteristics of place such as landforms, bodies of water, Earth's resources, and weather	**ELAR.K.6.A** describe personal connections to a variety of sources **ELAR.K.12.C** gather information from a variety of sources with adult assistance	**TA.K.4.A** communicate an understanding that data is information collected about people, events, or objects such as computer searches and weather patterns
Science.K.12.A observe and identify the dependence of plants on air, sunlight, water, nutrients in the soil, and space to grow **Career Highlights:** Soil & Plant Scientists, Biologists, Farmworkers & Laborers, Crop, Nursery, & Greenhouse			**ELAR.K.12.A** generate questions for formal and informal inquiry with adult assistance	**TA.K.4.A** communicate an understanding that data is information collected about people, events, or objects such as computer searches and weather patterns

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Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.K.12.B observe and identify the dependence of animals on air, water, food, space, and shelter **Career Highlights:** Biologists, Zoologists and Wildlife, Environmental Science and Protection Technicians		**SS.K.5.A** identify basic human needs of food, clothing, and shelter **SS.K.5.B** explain the difference between needs and wants **SS.K.5.C** explain how basic human needs and wants can be met	**ELAR.K.5.B** generate questions about text before, during, and after reading to deepen understanding and gain information with adult assistance	**TA.K.4.A** communicate an understanding that data is information collected about people, events, or objects such as computer searches and weather patterns
Science.K.13.A identify the structures of plants, including roots, stems, leaves, flowers, and fruits **Career Highlights:** Soil & Plant Scientists, Biologists, Farmworkers & Laborers, Crop, Nursery, & Greenhouse			**ELAR.K.3.B** use illustrations and texts the student is able to read or hear to learn or clarify word meanings **ELAR.K.5.H** synthesize information to create new understanding with adult assistance	
Science.K.13.B identify the different structures that animals have that allow them to interact with their environment such as seeing, hearing, moving, and grasping objects **Career Highlights:** Biologists, Zoologists and Wildlife, Geneticists			**ELAR.K.3.B** use illustrations and texts the student is able to read or hear to learn or clarify word meanings **ELAR.K.5.H** synthesize information to create new understanding with adult assistance	

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Science Student Expectation	Math Connection	Social Studies Connection	Reading Language Arts Connection	Technology Applications Connection
Science.K.13.C identify and record the changes from seed, seedling, plant, flower, and fruit in a simple plant life cycle **Career Highlights:** Biologists, Soil & Plant Scientists, Bioengineers and Biomedical Engineers	**Math.K.1.E** create and use representations to organize, record, and communicate mathematical ideas		**ELAR.K.12.C** gather information from a variety of sources with adult assistance	**TA.K.4.A** communicate an understanding that data is information collected about people, events, or objects such as computer searches and weather patterns
Science.K.13.D identify ways that young plants resemble the parent plant **Career Highlights:** Biologists, Soil & Plant Scientists, Bioengineers and Biomedical Engineers, Geneticists	**Math.K.6.D** identify attributes of two- dimensional shapes using informal and formal geometric language interchangeably		**ELAR.K.5.G** evaluate details to determine what is most important with adult assistance **ELAR.K.5.H** synthesize information to create new understanding with adult assistance **ELAR.K.12.C** gather information from a variety of sources with adult assistance	

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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.