Unit 1: Engineering

Content Area: **Template**
Course(s):
Time Period: **Full Year**
Length: **Full Year**
Status: **Published**

UNIT RATIONALE

The first unit, Introduction to Engineering and Design Thinking, aims to introduce students to the fundamental concepts and principles of engineering and develop their design thinking skills. Through hands-on activities, problem-solving challenges, and collaborative projects, students will explore the engineering design process, learn about different engineering disciplines, and engage in creative problem-solving.

ESSENTIAL QUESTIONS

1. What is engineering, and how does it impact our daily lives?
2. How can we apply design thinking to solve real-world problems?
3. What are the key steps of the engineering design process, and how do they contribute to successful outcomes?
4. How can collaboration and teamwork enhance the engineering and design process?

STANDARDS

NEW JERSEY STUDENT LEARNING STANDARDS: CONTENT AREA

NEW JERSEY STUDENT LEARNING STANDARDS: CONTENT AREA *PUBLIC*
SAVED

New Jersey (NJSLS) - Grade 8 - Mathematics (2020)

8.NS.A.2

Use rational approximations of irrational numbers to compare the size of irrational numbers, locate them approximately on a number line diagram, and estimate the value of expressions (e.g., π2). For example, by truncating the decimal expansion of √2, show that √2 is between 1 and 2, then between 1.4 and 1.5, and explain how to continue on to get better approximations.

8.G.A

Understand congruence and similarity using physical models, transparencies, or geometry software.

8.G.A.1

Verify experimentally the properties of rotations, reflections, and translations:

8.G.A.1.a

Lines are transformed to lines, and line segments to line segments of the same length.

8.G.A.1.b

Angles are transformed to angles of the same measure.

8.G.A.1.c

Parallel lines are transformed to parallel lines.

8.G.A.2

Understand that a two-dimensional figure is congruent to another if the second can be obtained from the first by a sequence of rotations, reflections, and translations; given two congruent figures, describe a sequence that exhibits the congruence between them.

8.G.A.3

Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates.

8.G.A.4

Understand that a two-dimensional figure is similar to another if the second can be obtained from the first by a sequence of rotations, reflections, translations, and dilations; given two similar two-dimensional figures, describe a sequence that exhibits the similarity between them.

8.G.A.5

Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so.

8.G.B

Understand and apply the Pythagorean Theorem.

8.G.B.6

Explain a proof of the Pythagorean Theorem and its converse.

8.G.B.7

Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions.

8.G.B.8

Apply the Pythagorean Theorem to find the distance between two points in a coordinate system.

8.G.C

Solve real-world and mathematical problems involving volume of cylinders, cones, and spheres.

8.G.C.9

Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems.

New Jersey (NJSLS) - Grades 6-8 - Computer Science and Design Thinking (2020)

8.2.8.ED.1:

Evaluate the function, value, and aesthetics of a technological product or system, from the perspective of the user and the producer.

8.2.8.ED.2:

Identify the steps in the design process that could be used to solve a problem.

8.2.8.ED.3:

Develop a proposal for a solution to a real-world problem that includes a model (e.g., physical prototype,

graphical/technical sketch).

8.2.8.ED.4:

Investigate a malfunctioning system, identify its impact, and explain the step-by-step process used to troubleshoot, evaluate, and test options to repair the product in a collaborative team.

8.2.8.ED.5:

Explain the need for optimization in a design process.

8.2.8.ED.6:

Analyze how trade-offs can impact the design of a product.

8.2.8.ED.7:

Design a product to address a real-world problem and document the iterative design process, including decisions made as a result of specific constraints and trade-offs (e.g., annotated sketches).

MA.8.NS.A.2	Use rational approximations of irrational numbers to compare the size of irrational numbers, locate them approximately on a number line diagram, and estimate the value of expressions (e.g., π^2).
MA.8.G.A	Understand congruence and similarity using physical models, transparencies, or geometry software.
MA.8.G.A.1	Verify experimentally the properties of rotations, reflections, and translations:
MA.8.G.A.1a	Lines are transformed to lines, and line segments to line segments of the same length.
MA.8.G.A.1b	Angles are transformed to angles of the same measure.
MA.8.G.A.1c	Parallel lines are transformed to parallel lines.
MA.8.G.A.2	Understand that a two-dimensional figure is congruent to another if the second can be obtained from the first by a sequence of rotations, reflections, and translations; given two congruent figures, describe a sequence that exhibits the congruence between them.
MA.8.G.A.3	Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates.
MA.8.G.A.4	Understand that a two-dimensional figure is similar to another if the second can be obtained from the first by a sequence of rotations, reflections, translations, and dilations; given two similar two-dimensional figures, describe a sequence that exhibits the similarity between them.
MA.8.G.A.5	Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles.
MA.8.G.B	Understand and apply the Pythagorean Theorem.
MA.8.G.B.6	Explain a proof of the Pythagorean Theorem and its converse.
MA.8.G.B.7	Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions.
MA.8.G.B.8	Apply the Pythagorean Theorem to find the distance between two points in a coordinate system.
MA.8.G.C	Solve real-world and mathematical problems involving volume of cylinders, cones, and spheres.
MA.8.G.C.9	Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems.
CS.6-8.8.2.8.ED.1	Evaluate the function, value, and aesthetics of a technological product or system,

	from the perspective of the user and the producer.
CS.6-8.8.2.8.ED.2	Identify the steps in the design process that could be used to solve a problem.
CS.6-8.8.2.8.ED.3	Develop a proposal for a solution to a real-world problem that includes a model (e.g., physical prototype, graphical/technical sketch).
CS.6-8.8.2.8.ED.4	Investigate a malfunctioning system, identify its impact, and explain the step-by-step process used to troubleshoot, evaluate, and test options to repair the product in a collaborative team.
CS.6-8.8.2.8.ED.5	Explain the need for optimization in a design process.
CS.6-8.8.2.8.ED.6	Analyze how trade-offs can impact the design of a product.
CS.6-8.8.2.8.ED.7	Design a product to address a real-world problem and document the iterative design process, including decisions made as a result of specific constraints and trade-offs (e.g., annotated sketches).

NEW JERSEY STUDENT LEARNING STANDARDS: CAREER READINESS, LIFE LITERACIES AND KEY SKILLS

MA.8.NS.A.2	Use rational approximations of irrational numbers to compare the size of irrational numbers, locate them approximately on a number line diagram, and estimate the value of expressions (e.g., π^2).
MA.8.G.A	Understand congruence and similarity using physical models, transparencies, or geometry software.
MA.8.G.A.1	Verify experimentally the properties of rotations, reflections, and translations:
MA.8.G.A.1a	Lines are transformed to lines, and line segments to line segments of the same length.

NEW JERSEY STUDENT LEARNING STANDARDS: COMPUTER SCIENCE AND DESIGN THINKING

CS.6-8.8.1.8.CS.1	Recommend improvements to computing devices in order to improve the ways users interact with the devices.
CS.6-8.8.1.8.CS.2	Design a system that combines hardware and software components to process data.
CS.6-8.8.1.8.CS.3	Justify design decisions and explain potential system trade-offs.
CS.6-8.8.1.8.CS.4	Systematically apply troubleshooting strategies to identify and resolve hardware and software problems in computing systems.

PRE-ASSESSMENTS

1. Pre-assessment Survey: Create a survey with questions that assess students' prior knowledge, experiences, and interests related to engineering and design thinking. Ask questions about their familiarity with engineering concepts, their understanding of the design process, and any previous engineering projects they have worked on.

2. Design Challenge Brainstorm: Present a design challenge to students and ask them to brainstorm possible solutions or design ideas individually or in small groups. This will help you gauge their creativity, critical thinking skills, and initial understanding of the design process.

3. Engineering Vocabulary Quiz: Administer a short quiz that tests students' knowledge of engineering-related vocabulary. Include terms such as prototype, constraints, criteria, iteration, and other key terms associated with engineering and design thinking.

INSTRUCTIONAL PLAN

MODULE 1

Subtopic 1: Foundations of Engineering

Subtopic 2: Design Thinking Processes

Subtopic 3: Tools and Technologies

Subtopic 4: Communication and Collaboration

Major Projects:

Floor Plan

Elevation

House build out of balsa wood

Upcycling

Subtopic 1.1

Subtopic 1.1: Foundations of Engineering

Essential Questions:
1. What is engineering, and what are the different disciplines within engineering?
2. What are the fundamental principles and concepts of engineering?
3. How does the engineering design process facilitate problem-solving and innovation?

Success Criteria:
By the end of this subtopic, students will be able to:
1. Define engineering and its various disciplines.
2. Explain the key principles and concepts of engineering.
3. Apply the engineering design process to solve simple problems.

Learning Intentions:
1. Develop an understanding of the field of engineering and its significance in various industries.
2. Explore the foundational concepts and principles that underpin engineering.

3. Cultivate problem-solving and critical thinking skills through the application of the engineering design process.

Learning Strategies:
1. Class discussions and presentations: Engage students in discussions about different engineering disciplines and their applications.
2. Hands-on activities: Conduct simple engineering design challenges that involve identifying problems, brainstorming solutions, and prototyping.
3. Research projects: Assign students to research and present on specific engineering disciplines or notable engineers.
4. Guest speakers: Invite professionals from different engineering fields to share their experiences and insights.

NJ Computer Science Standards:
- CSTA Standards: CT.L1, CT.L2, CT.L3

NJ Design Thinking Standards:
- Engage in an iterative design process, developing and refining multiple ideas. (DT.CS.1)
- Collaborate effectively in teams, valuing the contributions of others. (DT.CS.2)

Unit 1, Subtopic 1.1 Projects:
1. Design and build a bridge using simple materials like popsicle sticks or straws to test its strength and load-bearing capacity.
2. Create a poster or infographic that highlights different engineering disciplines, their applications, and notable achievements.
3. Construct a simple machine using household materials that performs a specific task or solves a problem.
4. Develop a design portfolio showcasing various design challenges, sketches, and prototypes created during the subtopic.
5. Collaboratively design and build a mini-catapult to launch projectiles and explore concepts of motion and energy transfer.

Subtopic 1.2

Subtopic 1.2: Design Thinking Process

Essential Questions:
1. What is design thinking, and how does it contribute to problem-solving and innovation?
2. What are the stages of the design thinking process, and how do they support creative problem-solving?
3. How can empathy and user-centered approaches enhance the effectiveness of design solutions?

Success Criteria:
By the end of this subtopic, students will be able to:
1. Define design thinking and its key principles.
2. Apply the stages of the design thinking process to real-world problem-solving.
3. Incorporate empathy and user-centered approaches in the development of design solutions.

Learning Intentions:
1. Understand the concept and significance of design thinking in various fields.
2. Explore the stages of the design thinking process and their role in problem-solving.
3. Foster empathy and user-centered thinking to develop innovative and effective design solutions.

Learning Strategies:
1. Design challenges: Engage students in design challenges that require empathy, ideation, prototyping, and testing.
2. Case studies: Analyze real-life examples of design thinking in action, such as product design or social innovation.
3. Design journals: Encourage students to maintain design journals to document their design thinking process and reflections.
4. Design critiques: Facilitate peer feedback sessions to evaluate and improve design solutions.

NJ Computer Science Standards:
- CSTA Standards: CT.L4, CT.L5, CT.L6

NJ Design Thinking Standards:
- Identify opportunities and constraints and generate creative solutions using a human-centered approach. (DT.CS.3)

- Apply systems thinking to understand the complex relationships between problems and solutions. (DT.CS.4)

Unit 1, Subtopic 1.2 Projects:
1. Conduct an empathy-based design challenge, such as designing a product or service that improves the daily life of a specific user group.
2. Create a storyboard or prototype for a mobile application that addresses a social or environmental issue.
3. Develop a user-centered design solution for optimizing a classroom or school space based on the needs and preferences of students.
4. Collaboratively design and build a functional Rube Goldberg machine that incorporates multiple steps and interactions.
5. Design and present a sustainable packaging solution for a common consumer product, considering material choices and environmental impact.

Subtopic 1.3

Subtopic 1.3: Engineering Design Tools and Technologies

Essential Questions:
1. What are the different tools and technologies used in engineering design?
2. How do engineering design software and digital technologies enhance the design process?
3. What are the benefits and limitations of using computer-aided design (CAD) software and other engineering tools?

Success Criteria:
By the end of this subtopic, students will be able to:
1. Identify and describe various tools and technologies used in engineering design.
2. Utilize computer-aided design (CAD) software to create 2D and 3D models.
3. Evaluate the advantages and limitations of using engineering design tools and technologies.

Learning Intentions:
1. Familiarize students with a range of tools and technologies commonly used in engineering design.
2. Develop proficiency in using computer-aided design (CAD) software for creating digital models.
3. Foster critical thinking skills to assess the effectiveness and appropriateness of different engineering design tools.

Learning Strategies:
1. Demonstrations and tutorials: Provide demonstrations and tutorials on engineering design software and tools.
2. Hands-on activities: Engage students in activities that require the use of specific tools, such as drafting, measurement, or prototyping tools.
3. Virtual design challenges: Assign design challenges that can be completed using CAD software or online design platforms.
4. Guest speakers or industry visits: Invite professionals or arrange visits to engineering firms or manufacturing facilities to explore real-world design tools and technologies.

NJ Computer Science Standards:
- CSTA Standards: CT.L1, CT.L2, CT.L3, CT.L4

NJ Design Thinking Standards:
- Develop and use criteria to guide the development of innovative solutions. (DT.CS.7)
- Demonstrate openness and persistence in the face of ambiguity, complexity, and uncertainty. (DT.CS.8)

Unit 1, Subtopic 1.3 Projects:
1. Use CAD software to design and 3D print a custom-made keychain or small object.
2. Create a digital model of a sustainable building design using architectural design software.
3. Construct a scale model of a vehicle or structure using a combination of traditional model-making materials and computer-generated parts.
4. Design a product prototype using a combination of hand sketching and digital rendering tools.
5. Explore virtual reality (VR) or augmented reality (AR) technologies to create a virtual walkthrough of a conceptual design or engineering project.

Subtopic 1.4

Subtopic 1.4: Communication and Collaboration in Engineering

Essential Questions:
1. How do engineers communicate and collaborate effectively in team environments?

2. What are the key elements of successful engineering documentation and presentation?
3. How can effective communication skills contribute to the success of engineering projects?

Success Criteria:
By the end of this subtopic, students will be able to:
1. Demonstrate effective communication and collaboration skills in team settings.
2. Prepare clear and concise engineering documentation, such as technical drawings or project reports.
3. Deliver well-structured and engaging presentations to communicate engineering ideas and solutions.

Learning Intentions:
1. Develop teamwork and collaboration skills required for engineering projects.
2. Enhance written and oral communication skills necessary for documenting and presenting engineering designs.
3. Promote critical thinking and problem-solving through effective communication and collaboration.

Learning Strategies:
1. Group projects: Assign collaborative engineering projects that require teamwork and division of tasks.
2. Presentation skills training: Provide guidance and practice opportunities for delivering effective presentations.
3. Engineering documentation exercises: Assign tasks that involve creating technical drawings, project reports, or design briefs.
4. Peer feedback sessions: Conduct peer evaluations to improve communication and collaboration skills.

NJ Computer Science Standards:
- CSTA Standards: CT.L3, CT.L5, CT.L6

NJ Design Thinking Standards:
- Present creative solutions to peers, including the rationale for decisions made. (DT.CS.5)
- Seek and incorporate feedback from users and other stakeholders. (DT.CS.6)

Unit 1, Subtopic 1.4 Projects:
1. Collaboratively design and build a functional prototype of a sustainable energy system, documenting the design process and presenting the final solution.
2. Prepare a technical drawing set for a simple mechanical device, including detailed drawings and assembly instructions.
3. Create a multimedia presentation that highlights the engineering design process and showcases a significant engineering project or innovation.
4. Develop a project proposal and pitch for an engineering solution to a real-world problem, considering technical, economic, and environmental factors.
5. Participate in a team-based engineering challenge, such as building a tower or bridge, and document the team's collaboration and problem-solving process.

REFLECTIONS

For this project, choices and parameters within those choices should be given in order to make sure projects meet

rubric standards and rigor.

INTERDISCIPLINARY CONNECTIONS: NEW JERSEY STUDENT LEARNING STANDARDS FOR ELA, SOCIAL STUDIES, SCIENCE AND/OR MATHEMATICS

Cross-Curricular Standards for Unit 1:

1. Language Arts:

- CCSS.ELA-LITERACY.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
- CCSS.ELA-LITERACY.WHST.6-8.2.D: Use precise language and domain-specific vocabulary to inform about or explain the topic.

2. Math:

- CCSS.MATH.CONTENT.6.EE.B.8: Write an inequality of the form x > c or x < c to represent a constraint or condition in a real-world or mathematical problem.
- CCSS.MATH.CONTENT.6.G.A.1: Find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes.

3. Science:

- NGSS.MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment.
- NGSS.MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

4. Social Studies:

- NCSS.C3.D2.Civ.3: Explain how groups of people make decisions about public issues and policies in different settings, including Native American tribal councils, constitutional conventions, legislatures, and special-interest groups.