

Theme

“A problem is a chance for you to do your best.” - Duke Ellington

STEM Innovation Academy Unit 1

Subject: Engineering Design and Development Unit Title: Researching a Problem Grade: 12th	Teacher: Mrs. Allison Braizer-Martin Duration: 9 weeks; September - November
Summary of Unit	
<p>This unit introduces students to the Engineering Design and Development Process. Students will work in teams to learn and apply the engineering design and development process to concisely define a problem. A problem statement is the foundation upon which all problem-solving effort is based. The problem statement allows students to focus effort. Students will validate the problem by documenting credible sources and indicate that the problem exists. They will justify the problem by performing additional research, including market research to confirm that the effort involved with solving the problem are warranted based on current need and projected need of a product. At the end of this unit, students will create a project proposal in which they will formally validate and justify the problem selected.</p>	
Stage 1 – Desired Results	
Standards/Outcomes:	
New Jersey Student Learning Standards for Engineering Design	
<ul style="list-style-type: none">● HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.● HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	
New Jersey Student Learning Standards for English Language Arts	
Progress Indicators for Reading Informational Text - Key Ideas and Details	
<ul style="list-style-type: none">● RI.11-12.1. Accurately cite strong and thorough textual evidence, (e.g., via discussion, written response, etc.), to support analysis of what the text says explicitly as well as inferentially, including determining where the text leaves matters uncertain. Research to Build and Present Knowledge	
Anchor Standards for Writing - Research to Build and Present Knowledge	
<ul style="list-style-type: none">● NJSLSA.W7. Conduct short as well as more sustained research projects, utilizing an inquiry-based research process, based on focused questions, demonstrating understanding of the subject under investigation.	
Progress Indicators for Writing	
<ul style="list-style-type: none">● W.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when	

appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

New Jersey Student Learning Standards for Mathematics

- N.Q.1 - Quantities Use units as a way to understand problems and to guide the solution of multi step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- N.Q.2 - Quantities Define appropriate quantities for the purpose of descriptive modeling.

2020 New Jersey Student Learning Standards – Career Readiness, Life Literacies, and Key Skills

- 9.2.12.CAP.2: Develop college and career readiness skills by participating in opportunities such as structured learning experiences, apprenticeships, and dual enrollment programs.
- 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas.
- 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice.
- 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving.
- 9.4.12.CT.3: Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).

2020 New Jersey Student Learning Standards – Computer Science and Design Thinking

Engineering Design

- 8.2.12.ED.1: Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers.

Essential Questions:

1. How can one establish the validity of a problem?
2. Why is it important to begin a design project with a valid problem statement?
3. How are experts and mentors valuable to the design process?
4. How can valuable and credible research be identified for use?
5. Why should an individual or company be concerned with justification of the problem?
6. How is market research used to aid research and development?
7. What exactly is the problem? How do I phrase it as an objective problem statement?
8. What is the background, context or setting of the problem?
9. Who says that this is a problem worth solving and why should anyone believe them?
10. What are all the methods, products or actions that are being used or have been developed to try to solve this problem? Exactly, why doesn't each of them actually solve the problem?
11. How do we prove to others that I/we have done an extensive search for possible current solution attempts?
12. Who has helped me/us identify and state the shortcomings of the solution attempts found and why should anyone believe them?

13. Now that I know what the problem statement is and why current solutions are not solving the problem well enough, what are the measurable things a new design would have to accomplish in order of importance to be seen as a real solution?
14. How did I/we determine each of these design requirements?

Enduring Understandings: *Students will understand that...*

- An accurately written problem statement identifies a need and guides the design process that will be used in engineering design problems.
- An accurately written problem statement aids in determining whether the result of the engineering design and development process has solved the identified problem.
- Experts are professionals who have specific knowledge in an area of interest and can guide the research needed for accurate justification and solutions to design problems.
- Market research aids business and industry in making better decisions about the development and marketing of new products.
- Effective market research focuses on potential users and buyers to gauge whether a problem is worth the investment required for it to be solved.
- Most innovations and inventions require time and capital that are not available to individuals, so it is necessary to communicate the need and available market to an entity that can provide the necessary resources.
- Engineers use math and science principles, concepts, and laws to solve problems.

Stage 2 – Assessment Evidence

Formative, Summative and Authentic Assessments:

- Engineering Design Process
- Engineering Notebook Documentation
- Problem Statements
- Research Articles
- Survey Questions
- Patent Research
- Market Research
- Analysis of Survey Data
- Project Proposal
- APA Citation

Presentation:

- Students will formally present all Element work and research through their engineering notebook documentation and portfolio
- Students will work in teams to orally present and document their problem ideas as if they were pitching their idea to an expert

Summative Assessment:

- Quizzes and Tests: Multiple Choice, Fill-in-the-Blank, Short Answer
- Unit Test

Performance Task(s):

Component 1: Researching a Problem

Element A – Identification and Justification of a Problem

Activity 1.0: Choosing a Problem. Students will individually propose five problems for five topics of consideration. For each problem, students will collect three credible sources that indicate that the problem exists.

Activity 1.1: Forming Teams: Students will form teams based on expressing interest in proposed topics. Students will facilitate an effective team environment to promote successful goal attainment, contribute individually to overall collaborative efforts, analyze and evaluate the work of others to provide helpful and effective feedback, communicate effectively and manage project timelines and resources as part of the engineering design process.

Activity 2.0: Developing a Problem Statement: Students will collaborate in their teams to write a problem statement that identifies reason/s that justifies the creation of a product to solve a problem.

Activity 2.5: Becoming an Expert: Students will collaborate in their teams to create a brochure or brief presentation that can be used as a tool to capture the project's focus and why it is worth pursuing. As the project moves forward, this document will be used to communicate the major points of the project to a general audience or to help secure financial backing from organizations and businesses.

Activity 3.0: Justifying a Problem Academically and Ethically: Students will conduct significant research to gather information, summarize articles and make judgments and decisions based on evidence to justify that their proposed problem exists. When doing research students will properly cite references for all documentation in APA format.

Activity 4.0: Knowledge of the Marketplace: Students will use their research from Activity 1.0 Choosing a Problem Activity 3.0 and Justifying a Problem Academically and Ethically to conduct additional research, to gather information about existing products that address their team's problem. For each existing similar product that is identified, students will describe the product (including images), explain why the product solution falls short, and detail why their solution will be more valuable or desirable.

Activity 4.1: Identifying Target Audience: Students will also identify and describe in detail the anticipated users and buyers of their anticipated target market (including, at a minimum, their age, income, education level, and geographic location) and explain why this is or should be the target market.

Activity 4.4: Conducting Market Research Surveys: Students will plan and perform direct market research by creating and conducting surveys to help define and justify their problem. Using Surveys is generally the best way to obtain responses from a large number of individuals. Students will analyze the results of their survey to determine consumer/user wants and needs.

Activity 4.5: Engineering Notebook Documentation: Students will document the design process in an engineering notebook according to best practices, explain the role of research in the process of design, find relevant data in credible sources such as literature, databases, and policy documents.

Element B – Document and Analysis of Prior Solution Attempts

Activity 1.0: Research and Documentation and of Solution Attempts: Students will research and

document plausible prior attempts to solve the problem and/or related problems drawn from a wide array of clearly identified and consistently credible sources such as patents and products that are currently on the market.

Activity 1.1: Analysis of Prior and Existing Similar Solution Attempts: Students will analyze past and current solution attempts to solve the problem—including both strengths and shortcomings. Documentation of the analysis is consistently clear, detailed, and supported by relevant data.

Activity 1.2: Similar Solutions Matrix: Students will develop and carry out a justifiable scheme to compare and evaluate competing prior, existing and similar solutions. A decision matrix will be used to compare and evaluate competing existing and similar solutions based on design criteria.

Activity 1.3: Engineering Notebook Documentation: Students will document the design process in an engineering notebook according to best practices, explain the role of documenting and analyzing prior and existing solution attempts, find relevant data in credible sources such as literature and databases.

Element C – Presentation and Justification of Solution Requirements

Activity 1.0: Defining Design Goals and Design Requirements: Students will incorporate their documentation and analysis of the survey data results to create a Voice of the Customer Document that details the wants and needs of the customer.

Activity 1.1: Design Specifications: Students will develop a consistently clear and detailed Design Specifications Document that lists and prioritizes design requirements that are highly likely leads to a tangible and viable solution to the problem identified.

Activity 1.2: Project Proposal: Students will create an electronic project proposal document. It will include all sections of Element A, B and C. This proposal is designed to help organize the team's work to date, synthesize the knowledge gained, and plan for the input of information that still needs to be gathered.

Activity 1.3: Engineering Notebook Documentation: Students will document the design process in an engineering notebook according to best practices and explain the role of documenting design specifications.

National Hispanic Heritage Month: September 15th - October 15th

1) Design a Poster or Travel Brochure

Let's get our passport ready! Students will take part in Virtual Trips to different Hispanic Countries. Students will watch videos on the different Hispanic countries and design a poster or travel brochure. Poster will include historical information and pictures of food, culture, musical instruments, national flag, clothing, historical artifacts, tourist attractions etc. Students will also include 1 thing that stood out to them about their visit to that country or that they liked most about the country.

2) Hispanic Influencers/Contributors in STEM and Engineering

Students will research different Hispanic Influencers and Contributors in the STEM and Engineering field. In this activity students will use the researched information to write a short autobiography on their chosen person. Students will share their autobiographies in class.

3) *Trivia*

Students will take part in a Hispanic History/Culture trivia game. Students will be placed in groups. Each group will take turns asking questions. Points will be given for each correct answer. Points gained during activity will be used as extra credit.

4) *Design a Ponce Mask*

Students will take part in a virtual visit of The National Museum of American History and explore the Hispanic Heritage artifacts, specifically the Puerto Rican Ponce Mask. Students will design and make their own Ponce mask.

Extensions (Tier I):

- More problem-solving challenges for students to validate and justify a problem to foster mastery.
- Brainstorm possible experts to contact
- Career Profiles- Give students insight into what jobs in certain engineering careers would look like through PLTW provided career profiles
- Office Hour Appointments

Differentiation (Tier II):

- Group work will allow high-tier students to support low-tier students to validate and justify a problem in problem-solving challenges for the mastery of Problem-Solving.
- Option for video on Defining the Problem
- Peer Tutoring
- One on one discussions
- Office Hour Appointments

Tier (III):

- Students will be provided with aid to develop various problem statements according to the Five W's -Who, What, Why, When, and Where also How which will allow students to create defined problem statements and solutions appropriate for their design and modeling skills
- Option for video on Defining the Problem <https://www.youtube.com/watch?v=iwddgAoGBqg&feature=youtu.be>
- Peer Tutoring
- One on one discussions
- Office Hour Appointments

Stage 3 – Learning Plan

Project Lead the Way (PLTW)

Engineering Design and Development Digital Textbook (password required):

<https://pltw.read.inkling.com/a/b/86a1841d86674ba5b7e3e00a55ccd89e/p/5cd7d7ae69aa45cb94c754e5cef6beca>

The EDD Digital Textbook linked above includes informational text, videos procedures, project requirements, presentations, and technical drawings used in the design of the learning tasks described in the stage 2 section of this unit plan.

Vocabulary

Engineering / Design Process / Problem-solving / Problem statement / Concise / Valid / Justify / Research / Resources / Brainstorming / Documentation / Analysis / Interviews / Surveys / Product / Market Research/ Consumer / Expert / Patent / Similar Solutions / Similar Solutions Matrix / Constraint / Criteria /Specifications / Project Proposal

Expert/Field Experience(s)

- Potential Field Trips: South Orange Public Library, Patent Office, EDD Project Showcase
- Potential Guest Speakers: Engineer, Patent Lawyer

Literacy Connections/Research

- Students will incorporate research into justifying a problem.
- Interesting articles will give students the opportunity to read about problems, similar solutions and existing products.
- Patents will allow students to explore the legal language regarding designs, which can then be discussed as a class.

Special Education/ 504:

English Language Learners:

<ul style="list-style-type: none"> -Adhere to all modifications and health concerns stated in each IEP. -Give students a MENU options, allowing students to pick assignments from different levels based on difficulty. -Accommodate Instructional Strategies: reading aloud text, graphic organizers, one-on-one instruction, class website (Google Classroom), handouts, definition list with visuals, extended time -Allow students to demonstrate understanding of a problem by drawing the picture of the answer and then explaining the reasoning orally and/or writing , such as Read-Draw-Write -Provide breaks between tasks, use positive reinforcement, use proximity -Assure students have experiences that are on the Concrete- Pictorial- Abstract spectrum by using manipulatives -Implement supports for students with disabilities (click here) - Make use of strategies imbedded within lessons -Common Core Approach to Differentiate Instruction: Students with Disabilities (pg 17-18) 	<ul style="list-style-type: none"> - Use manipulatives to promote conceptual understanding and enhance vocabulary usage - Provide graphic representations, gestures, drawings, equations, realia, and pictures during all segments of instruction - During i-Ready lessons, click on “Español” to hear specific words in Spanish - Utilize graphic organizers which are concrete, pictorial ways of constructing knowledge and organizing information - Use sentence frames and questioning strategies so that students will explain their thinking/ process of how to solve word problems - Utilize program translations (if available) for L1/ L2 students - Reword questions in simpler language - Make use of the ELL Mathematical Language Routines (click here for additional information) -Scaffolding instruction for ELL Learners -Common Core Approach to Differentiate Instruction: Students with Disabilities (pg 16-17)
Gifted and Talented:	Students at Risk for Failure:
<ul style="list-style-type: none"> - Elevated contextual complexity - Inquiry based or open ended assignments and projects - More time to study concepts with greater depth - Promote the synthesis of concepts and making real world connections - Provide students with enrichment practice that are imbedded in the curriculum such as: <ul style="list-style-type: none"> ● Application / Conceptual Development ● Are you ready for more? - Provide opportunities for math competitions - Alternative instruction pathways available - Common Core Approach to Differentiate Instruction: Students with Disabilities (pg. 20) 	<ul style="list-style-type: none"> - Assure students have experiences that are on the Concrete- Pictorial- Abstract spectrum - Modify Instructional Strategies, reading aloud text, graphic organizers, one-on-one instruction, class website (Google Classroom), inclusion of more visuals and manipulatives, Peer Support - Constant parental/ guardian contact - Provide academic contracts to students & guardians - Create an interactive notebook with samples, key vocabulary words, student goals/ objectives. - Plan to address students at risk in your learning tasks, instructions, and directions. Anticipate where the needs will be, then address them prior to lessons. -Common Core Approach to Differentiate Instruction: Students with Disabilities (pg 19)

21st Century Life and Career Skills:

Career Ready Practices describe the career-ready skills that all educators in all content areas should seek to develop in their students. They are practices that have been linked to increase college, career, and life success. Career Ready Practices should be taught and reinforced in all career exploration and

preparation programs with increasingly higher levels of complexity and expectation as a student advances through a program of study.

<https://www.state.nj.us/education/cccs/2014/career/9.pdf>

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| <ul style="list-style-type: none">● CRP1. Act as a responsible and contributing citizen and employee.● CRP2. Apply appropriate academic and technical skills.● CRP3. Attend to personal health and financial well-being.● CRP4. Communicate clearly and effectively and with reason.● CRP5. Consider the environmental, social and economic impacts of decisions.● CRP6. Demonstrate creativity and innovation. | <ul style="list-style-type: none">● CRP7. Employ valid and reliable research strategies.● CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.● CRP9. Model integrity, ethical leadership and effective management.● CRP10. Plan education and career paths aligned to personal goals.● CRP11. Use technology to enhance productivity.● CRP12. Work productively in teams while using cultural global competence. |
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Students are given an opportunity to communicate with peers effectively, clearly, and with the use of technical language. They are encouraged to reason through experiences that promote critical thinking and emphasize the importance of perseverance. Students are exposed to various mediums of technology, such as digital learning, calculators, and educational websites.

Technology Standards:

All students will be prepared to meet the challenge of a dynamic global society in which they participate, contribute, achieve, and flourish through universal access to people, information, and ideas.

<https://www.state.nj.us/education/cccs/2014/tech/>

8.1 Educational Technology:

All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.

- A. Technology Operations and Concepts: Students demonstrate a sound understanding of technology concepts, systems and operations.
- B. Creativity and Innovation: Students demonstrate creative thinking, construct knowledge and develop innovative products and process using
- C. technology.Communication and Collaboration: Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.
- D. Digital Citizenship: Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior.
- E. Research and Information Fluency: Students apply digital tools to gather, evaluate, and use of information.
- F. Critical thinking, problem solving, and decision making: Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.

Technology Education, Engineering, Design, and Computational Thinking - Programming:

All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.

- A. The Nature of Technology: Creativity and Innovation- Technology systems impact every aspect of the world in which we live.
- B. Technology and Society: Knowledge and understanding of human, cultural, and societal values are fundamental when designing technological systems and products in the global society.
- C. Design: The design process is a systematic approach to solving problems.
- D. Abilities in a Technological World: The designed world in a product of a design process that provides the means to convert resources into products and systems.
- E. Computational Thinking: Programming- Computational thinking builds and enhances problem solving, allowing students to move beyond using knowledge to creating knowledge.