Theme

"Design is not what it looks like and feels like. Design is how it works."- Steve Jobs

STEM Innovation Academy Unit 3

Subject: Engineering Design and Development Unit Title: Creating a Prototype and Testing Plan Grade: 12th	Teacher: Mrs. Allison Braizer-Martin Duration: 9 weeks; January - March

Summary of Unit

This unit is most exciting. Students will work in their teams to actively engage in the building of a well-designed and testable prototype. Teams will develop an agreed upon, step-by-step explanation of the assembly directions for the building of their prototype and will also have a design solution that satisfies all criteria. They will keep in mind that the materials used for their prototypes may have to be adjusted based on cost, availability and access to the equipment necessary for the fabrication process. Teams will perform several different tests, which may be conducted at different phases of the construction process. Teams will define and justify the testing method and they will need to demonstrate that they are using sound engineering, scientific, and mathematical principles. The collected test data will be evaluated against the criteria that the team established to determine success or failure. Teams will understand that the success or failure of the prototype is not the goal of engineering design and development. EDD is all about the process.

Stage 1 – Desired Results

Standards/Outcomes:

New Jersey Student Learning Standards for Engineering Design

- 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.
- HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
- HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

New Jersey Student Learning Standards for English Language Arts

Progress Indicators for Reading Informational Text - Key Ideas and Details

- 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

- 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

- 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.

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.
- 8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modifications to increase optimization based on feedback.

PLTW Science and Engineering Practices

- Design a test of a model to ascertain its reliability.
- Develop a complex model that allows for manipulation and testing of a proposed process or system.
- Developing and Using Models Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
- Planning and Carrying Out Investigations Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

Essential Questions:

1. What are the subsystems of products or systems that you are familiar with?
2. Which subsystems are essential to system function and which are enhancements?
3. What are the advantages of using virtual solutions before and sometimes in place of physical prototypes?
4. How does having a highly functional prototype relate to testing?
5. What steps can be taken to lower the cost of your prototype?
6. Why are test criteria important in test design?
7. How do you know that you have enough step-by-step detail in your test procedure?
8. What measurement practices are used to analyze your test results?
9. What is the significance of seeking input from experts or non-team members?
10. What is the plan to test the prototype design?
11. How can I show others that the testing plan for each design requirement is a well thought out test and would yield believable data?
12. What did I/we learn from testing about how well this design met the stated design requirements?
13. Why should others believe my/our analysis of the data?
14. What do end users and experts, who are directly related to this project and problem statement, think of the testing results and my/our conclusions about the effectiveness of this idea?

Enduring Understandings: *Students will understand that…*

- Material and equipment requirements are defined by creating a materials and cost analysis during the prototyping phase of a project.
- Virtual solutions for designs allow engineers to plan, test, and prepare for building a prototype.
- Designers must consider characteristics, such as strength and weight of materials, and fastening procedures to be sure that the final design meets design specifications.
- Prototypes can generally be broken down into subsystems to isolate problems and conduct incremental testing.
- Engineers write step-by-step instructions for the prototype assembly to guide the fabrication of the design solution.
- Prototyping provides the engineer with a scaled working model of the design solution.
- The construction of a physical model can enhance the quality, efficiency, and productivity of the final product.
- To gather useful data, specific criteria for success or failure of a test must be determined before testing begins.
- Prototype testing is a controlled procedure that is used to evaluate a specific aspect of a design solution.
- A detailed description of the testing procedure helps to ensure that the results of the design solution testing are valid.
- Data can be classified as either quantitative, because it can be measured, or qualitative , because it describes a quality or categorization.
- The results of prototype testing are used to refine the design and to improve the design solution.
- Design reviews are used at crucial stages of the design process to gather input and perspective to determine how to proceed with a design.

Stage 2 – Assessment Evidence

Unit Pre-Assessment:

- Element D, E, F

Formative, Summative and Authentic Assessments:

- Engineering Design Process
- Engineering Notebook Documentation
- Design Specifications
- 3D Modelling
- Prototype
- Prototype Testing
- Analysis of Test Results

Presentation:

- Students will formally present all Element work and research through their engineering notebook documentation and portfolio.
- Students will work in teams document and orally present and data collected through testing.

Summative Assessment:

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

Performance Task(s):

Component 3: Prototype and Test

Element G – Construction of a Testable Prototype

Activity 1.0: Prototype Planning and Documentation: Students will create a document to delineate the resources needed to construct their prototype. This document will include three categories of resources: bill of materials, tools and equipment, and needed knowledge.

Activity 1.2: Choosing Materials and Fastening Procedures: Each team member will list all parts and subsystems in their engineering notebooks that are most appropriate based on the criteria. Students will also identify which parts of their design needs special consideration because it will undergo specific stresses, weather conditions, or fatigue testing. Students will research and document scientific, mathematical, and engineering concepts that need to be considered for each and compile the considerations and do the necessary work to ensure that the material and fastening choices are influenced by scientific, mathematical, and engineering concepts.

Activity 1.3: Choosing Materials Checklist: Students will use the Materials Checklist to assess the materials and fastening procedures from Activity 1.2.

Activity 1.4: Build Procedure: Students will collaborate in their teams to write a description of how to build their prototype. Students will also compile the information and create the assembly procedure directions.

Activity 2.0: Opportunities for Incremental Testing Plan: Students will collaborate in their teams to identify subsystems in their design and determine how each must perform to be considered successful and determine the extent to which each subsystem or element should be tested.

Element H – Prototype Testing and Data Collection Plan

Activity 1.0: Test Criteria: Students will collaborate in their teams to determine the quantitative and qualitative testing criteria for their design solution by revisiting their design specifications and list the criteria/benchmarks that should be tested to ensure success and effectiveness of their product and by researching the ASTM standards for testing of the materials used in their design solution or devices that are similar to theirs.

Activity 1.2: Test Procedure: Students will specify a testing method that they will use to objectively measure the effectiveness of their solution and/or the parts of their solution based on the test criteria and consult experts to ensure that their team is using valid criteria and methods.

Element I – Testing, Data Collection, and Analysis

Activity 1.0: Test and Evaluate the Prototype: Students will collaborate in their teams to perform the testing procedure(s) at least three times and collect data for each test on the forms that were created in

Activity 1.2 Test Procedure. Students will collect pictures, screenshots, and data throughout the test procedure.

Activity 2.1: Redesign and Refine: Based on their final testing and critical design review, students will document a suitable and substantial plan for modifying their product design if necessary.

Black History Month: February 1st - March 1st

1) Design a Poster on Canva

Students will research Black Engineers or STEM contributors to create a poster on Canva to portray the life and accomplishments of the person of their choice. Poster should include historical information and pictures.

2) The Intellectual Property of Eli Whitney

Students will analyze Eli Whitney's patent for invention and the petition he filed with Congress concerning his invention. Students will summarize the documents and respond to the following questions; What was the loophole in the 1793 patent law? Why did Eli Whitney write the petition to Congress? What evidence did Eli Whitney have to support his petition?

3) Scavenger Hunt

Students will take part in a Black History Scavenger Hunt. Students will be placed in groups. Each group will be provided with the Black History Scavenger Hunt Worksheet. Each group will use their researching skills to figure out who each Scavenger Hunt description is describing. Points will be given for each correct answer. Points gained during activity will be used as extra credit.

4) Virtual Museum Tour

Students will take part in a virtual visit of The Black Inventor Online Museum to explore the ingenuity and accomplishments of Black Inventors over the last 300 years. Students will also choose one Black Inventor to write a biography on.

Extensions (Tier I):

- Mini Problem-Solving Challenges
- Research alternate materials
- Give opportunities for re-testing and data collection
- Office Hour Appointments

Differentiation (Tier II):

- Group work will allow high-tier students to support low-tier students in developing and testing prototype
- Provide aid in optimizing prototype and testing conditions
- Peer Tutoring
- One on one discussions
- Office Hour Appointments

Tier (III):

- Options for expert aid in prototyping and testing
- 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

Prototype / Model / Data / Test / Material/ ASTM / Quality Control / Test Procedures / Test Criteria / Quantitative / Qualitative / Results / Design Reviews

Expert/Field Experience(s)

- Potential Field Trips: Manufacturing/Industrial Plant, Machining Shops
- Potential Guest Speakers: Engineer, Designer, 3D Printer Specialist, Mechanical Engineer, Electrician

Literacy Connections/Research

- Students will incorporate research on prototyping, testing and data collection into their project.
- Students will research information about alternate materials and properties for their prototype.

Special Education/ 504:	English Language Learners:
-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)	- 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:**
- 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: ● 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)	- 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

- 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.
- 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.

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.