Theme

"Design is the intermediary between information and understanding."- Hans Hoffmann

STEM Innovation Academy Unit 2

Subject: Engineering Design and Development Unit Title: Designing a Solution Grade: 12th	Teacher: Mrs. Allison Braizer-Martin Duration: 9 weeks; November - January

Summary of Unit

Unit 2 requires students to work with their team to define the criteria and constraints associated with the solution to their selected problem and write a set of design specifications for the project. Based on the specifications, students will develop multiple potential solution concepts. Through an evaluation process that involves feedback and the application of a decision matrix, students will select the best potential solution to pursue. They will assess their selected solution path based on a variety of factors, consider the consequences of their solution, and optimize their design approach. Finally, students will write a design proposal and make an oral presentation for the purpose of justifying further development of the product.

Stage 1 – Desired Results

Standards/Outcomes:

New Jersey Student Learning Standards for Engineering Design

- 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.
- 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.

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.

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 modification to increase optimization based on feedback.

Essential Questions:

1. Why would an engineer need to identify the criteria and constraints required for a design solution?
2. How would you explain the following statement? "Finding a good solution is an iterative process."
3. Why is it important to take the time to thoroughly explore many potential solutions before selecting a solution path?
4. What benefit does optimization provide at this point in the design process?
5. What are the advantages of using virtual solutions before and sometimes in place of physical prototypes?
6. What brainstorming or idea generation techniques did I/we use to help define possible solutions?
7. How can we show that I/we kept all of the design requirements in mind throughout the entire process?
8. What was the best solution to try and why was it the best solution to try?
9. How do we show that our design ideas were not just guesses and that my/our ideas and each of the proposed design attributes really is based on sound logic and subject-related knowledge?
10. How do I/we show evidence that the proposed design has merit beyond the classroom or lab as a real solution?
11. How can I/we show evidence that the design could realistically get into the hands of the people the design is trying to help in a sustainable way?
12. What evidence would I/we have to offer to honestly ask a family to invest their life savings in this idea?

Enduring Understandings: *Students will understand that…*

- Specifications for a design solution provide clear parameters for a successful design solution.
- Engineers use a decision matrix to compare preliminary design solutions by assessing each alternate design based on the design requirements specified.
- A design should be continually checked and critiqued by experts and stakeholders to guide the design process and ensure a successful solution.
- Optimization improves the final design solution by aligning the solution with the specifications imposed.
- Multiple factors affect the commercial success of a consumer product.
- Drawings and sketches are used to organize, record, and communicate ideas.
- Engineers use working drawings to show all of the information needed to make a part, subassembly, or a complete design solution.
- Engineers use a peer review process to review and evaluate design solutions to provide feedback and implement necessary revisions.
- Engineers and designers have ethical responsibilities to clients, peers, their profession, and the general public.
- Product development will result in consequences, both good and bad, that must be considered when deciding whether or not to develop a product.
- A business plan formalizes the goals of a company and provides a plan for reaching those goals that can be used both to guide the company’s policies and strategies and to solicit outside support and financing.

Stage 2 – Assessment Evidence

Unit Pre-Assessment:

- Element A, B, C

Formative, Summative and Authentic Assessments:

- Engineering Design Process
- Engineering Notebook Documentation
- Decision Matrix
- Design Specifications
- Thumbnail Sketches
- Concept Sketches
- Mechanical Sketches
- Design Concept
- STEM Principles
- Design Viability
- 3D Modelling

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 the purpose of justifying further development of the product.

Summative Assessment:

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

Performance Task(s):

Component 2: Design

Element D – Design Concepts Generation, Analysis and Selection

Activity 1.0: Brainstorming Possible Solutions: Students will collaborate in their teams to brainstorm and record possible solutions to their problem. All team members will contribute to generating ideas and to stimulate creative thinking.

Activity 2.0: Concept Development: Students will review the design specification for their project, gather all of the documentation created from their team's brainstorming efforts and review the design ideas that were generated. Students will consider altering or combining documented ideas to create better concepts.

Activity 2.1: SCAMPER: Students will use the SCAMPER acronym to generate new and different ideas or approaches by creating thumbnail sketches to represent their design concept. Sketches are used to organize, record, and communicate ideas.

Activity 2.5: Design Concept Generation: Students will create detailed, annotated sketches to

communicate the design intent of their design concept. Each member will create their own annotated sketches and include it on a Product Concept Document that details the preliminary ideas about general size and shape, materials, and other product features that will be incorporated to address the design specification requirements.

Activity 3.0: Selecting the Best Solution: Students will create a Design Concept decision matrix to objectively compare their design concepts. The design specifications and customer needs are used as the basis of comparison to rate and rank each design concept. Based on the results of the decision matrix analysis, concepts can be eliminated, revised, or combined to create new and improved design concepts.

Activity 3.3: Product Improvement and Design Document: Students will collaborate in their teams to assess their preliminary conceptual design with respect to a variety of factors that could affect its commercial success such as product safety and potential liability, the global market and economy, the potential for other uses of the product, and the social trend toward environmental awareness and sustainability. Based on the results of their assessment, the team will optimize their design and move on to the next steps of the process to create CAD working drawings that they will use to create a prototype.

Activity 3.6: Concept Analysis: Students will collaborate in their teams to create a poster (or board) to present their conceptual solutions to potential consumers, stakeholders, and field experts. Evaluators will provide feedback to each team regarding their concepts. As a team you will then critically consider all of the feedback and incorporate appropriate suggestions for improvement.

Activity 4.0: Virtual Solutions – Creating Working Drawings: Students will collaborate in their teams to create technical drawings that are necessary to explain their team's design solution. Students will use CAD software.

Activity 4.1: Virtual Solutions – Creating Working Drawings: Students will use 3D modeling software to create annotated part files that make up their design solution. The 3D models will include all views, details, notes, and dimensions necessary to fully represent the part, so that it can be constructed without verbal instructions. Students will open an assembly drawing and bring in all the parts needed for the assembly. Assemble the parts and apply the necessary constraints.

Activity 5.0: Preliminary Design Review: Students will present working drawings for review and evaluation.

Activity 5.5: Engineering Notebook Documentation: Students will document the design process in an engineering notebook according to best practices, explain the design specifications and document preliminary designs.

Element E – Application of STEM Principles and Practices

Activity 1.0: STEM Principles and Practices: Students will create a document that accurately describes the relevant math and science concepts associated with the problem and solution. Students will use data, calculations, and practices of these disciplines to drive the decision-making process and defend their decision on important design goals.

Element F – Consideration of Design Viability

Activity 1.0: Viability of Proposed Solution: Students will complete a Design Viability Document to review whether their idea has any chance of succeeding as a real solution.

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<tr>
<td>Extensions (Tier I):

Mini Problem-Solving Challenges
Add more details to sketches
Additional criteria and/or constraints in design challenges
Give students opportunities to research materials to prepare for next unit
Office Hour Appointments

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<td>Differentiation (Tier II):

Group work will allow high-tier students to support low-tier students in adding details to optimize designs and sketches using SCAMPER
CAD Tutorial Videos will be provided to aid students
3D modeling Tutorial Videos will be provided to aid students
Peer Tutoring
One on one discussions
Office Hour Appointments

Tier (III):

Students will use SCAMPER Technique video to scaffold brainstorming of designs and sketches https://www.youtube.com/watch?v=G8w0rJhztJ4
CAD Tutorial Videos will be provided to aid students
3D modeling Tutorial Videos will be provided to aid students
Peer Tutoring
One on one discussions
Office Hour Appointments

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<tr>
<td colspan="2">Stage 3 – Learning Plan</td>
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<td colspan="2">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.</td>
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<tr>
<td colspan="2">Vocabulary</td>
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<td colspan="2">Concepts / Evaluation / Decision Matrix / Consequences / Designers / Evaluate / Aesthetics / Ergonomics / Analysis /Brainstorming / SCAMPER / Thumbnail Sketches / Analysis / STEM Principles / Design Viability / 3D Modeling</td>
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<td colspan="2">Expert/Field Experience(s)

Potential Field Trips: Local Business to conduct Interviews and surveys, EDD Project Showcase
Potential Guest Speakers: Engineer, Designer

Literacy Connections/Research

Students will incorporate research of similar solutions, existing products and patents.

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- Interesting articles will give students the opportunity to read about problems, similar solutions and existing products.
- Students will research information about potential material and properties for their designs.

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.