Readington Township Public Schools

Innovation & Design Grades 6-8

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Readington Township Public Schools
www.readington.k12.nj.us

OVERVIEW

The Innovation and Design Curriculum is based on the belief that much of the ingenuity of children is untapped, unrealized potential that, when properly motivated, will lead to the next generation of technologists, innovators, designers and engineers critical to our society. Our goal is to promote Science, Technology, Engineering and Mathematics (STEM) learning, innovative thinking and creative problem-solving.

STUDENT OUTCOMES (Linked to the New Jersey Student Learning Standards)

NJSLS- Science-Engineering Design

MS.ETS1.A: Defining and Delimiting Engineering Problems

MS.ETS1.B: Developing Possible Solutions

MS.ETS1.C: Optimizing the Design Solution

Computer Science and Design Thinking Practices

1. Fostering an Inclusive Computing and Design Culture
2. Collaborating Around Computing and Design
3. Recognizing and Defining Computational Problems
4. Developing and Using Abstractions
5. Creating Computational Artifacts
6. Testing and Refining Computational Artifacts
7. Communicating About Computing and Design

8.1 Computer Science

Computing Systems

8.1.8.CS.1: Recommend improvements to computing devices in order to improve the ways users interact with the devices.

8.1.8.CS.2: Design a system that combines hardware and software components to process data.

8.1.8.CS.3: Justify design decisions and explain potential system trade-offs.

8.1.8.CS.4: Systematically apply troubleshooting strategies to identify and resolve hardware and software problems in computing systems.

Networks and the Internet

8.1.8.NI.1: Model how information is broken down into smaller pieces, transmitted as addressed packets through multiple devices over networks and the Internet, and reassembled at the destination.

8.1.8.NI.2: Model the role of protocols in transmitting data across networks and the Internet and how they enable secure and errorless communication.

8.1.8.NI.3: Explain how network security depends on a combination of hardware, software, and practices that control access to data and systems.

8.1.8.NI.4: Explain how new security measures have been created in response to key malware events.

Impacts of Computing

8.1.8.IC.1: Compare the trade-offs associated with computing technologies that affect individual's everyday activities and career options.

8.1.8.IC.2: Describe issues of bias and accessibility in the design of existing technologies.

Data & Analysis

8.1.8.DA.1: Organize and transform data collected using computational tools to make it usable for a specific purpose.

8.1.8.DA.2: Explain the difference between how the computer stores data as bits and how the data is displayed.

8.1.8.DA.3: Identify the appropriate tool to access data based on its file format.

8.1.8.DA.4: Transform data to remove errors and improve the accuracy of the data for analysis.

8.1.8.DA.5: Test, analyze, and refine computational models.

8.1.8.DA.6: Analyze climate change computational models and propose refinements.

Algorithms & Programming
8.1.8.AP.1: Design and illustrate algorithms that solve complex problems using flowcharts and/or pseudocode.
8.1.8.AP.2: Create clearly named variables that represent different data types and perform operations on their values.
8.1.8.AP.3: Design and iteratively develop programs that combine control structures, including nested loops and compound conditionals.
8.1.8.AP.4: Decompose problems and sub-problems into parts to facilitate the design, implementation, and review of programs.
8.1.8.AP.5: Create procedures with parameters to organize code and make it easier to reuse.
8.1.8.AP.6: Refine a solution that meets users' needs by incorporating feedback from team members and users.
8.1.8.AP.7: Design programs, incorporating existing code, media, and libraries, and give attribution.
8.1.8.AP.8: Systematically test and refine programs using a range of test cases and users. 8.1.8.AP.9: Document programs in order to make them easier to follow, test, and debug.

8.2 Design Thinking
Engineering Design
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).
Interaction of Technology and Humans
8.2.8.ITH.1: Explain how the development and use of technology influences economic, political, social, and cultural issues.
8.2.8.ITH.2: Compare how technologies have influenced society over time.
8.2.8.ITH.3: Evaluate the impact of sustainability on the development of a designed product or system.
8.2.8.ITH.4: Identify technologies that have been designed to reduce the negative consequences of other technologies and explain the change in impact.
8.2.8.ITH.5: Compare the impacts of a given technology on different societies, noting factors that may make a technology appropriate and sustainable in one society but not in another.
Nature of Technology
8.2.8.NT.1: Examine a malfunctioning tool, product, or system and propose solutions to the problem.
8.2.8.NT.2: Analyze an existing technological product that has been repurposed for a different function.
8.2.8.NT.3: Examine a system, consider how each part relates to other parts, and redesign it for another purpose.
8.2.8.NT.4: Explain how a product designed for a specific demand was modified to meet a new demand and led to a new product.
Effects of Technology on the Natural World
8.2.8.ETW.1: Illustrate how a product is upcycled into a new product and analyze the short- and long-term benefits and costs.
8.2.8.ETW.2: Analyze the impact of modifying resources in a product or system (e.g., materials, energy, information, time, tools, people, capital).
8.2.8.ETW.3: Analyze the design of a product that negatively impacts the environment or society and develop possible solutions to lessen its impact.
8.2.8.ETW.4: Compare the environmental effects of two alternative technologies devised to address climate change issues and use data to justify which choice is best.

Ethics & Culture
8.2.8.EC.1: Explain ethical issues that may arise from the use of new technologies.
8.2.8.EC.2: Examine the effects of ethical and unethical practices in product design and development.

9.4 Life Literacies and Key Skills by the End of Grade 8
Creativity and Innovation
9.4.8.CI.1: Assess data gathered on varying perspectives on causes of climate change (e.g., crosscultural, gender-specific, generational), and determine how the data can best be used to design multiple potential solutions (e.g., RI.7.9, 6.SP.B.5, 7.1.NH.IPERS.6, 8.2.8.ETW.4).
9.4.8.CI.2: Repurpose an existing resource in an innovative way (e.g., 8.2.8.NT.3).
9.4.8.CI.3: Examine challenges that may exist in the adoption of new ideas (e.g., 2.1.8.SSH, 6.1.8.CivicsPD.2).
9.4.8.CI.4: Explore the role of creativity and innovation in career pathways and industries.

Critical Thinking and Problem-solving
9.4.8.CT.1: Evaluate diverse solutions proposed by a variety of individuals, organizations, and/or agencies to a local or global problem, such as climate change, and use critical thinking skills to predict which one(s) are likely to be effective (e.g., MS-ETS1-2).
9.4.8.CT.2: Develop multiple solutions to a problem and evaluate short- and long-term effects to determine the most plausible option (e.g., MS-ETS1-4, 6.1.8.CivicsDP.1).
9.4.8.CT.3: Compare past problem-solving solutions to local, national, or global issues and analyze the factors that led to a positive or negative outcome.

Technology Literacy
9.4.8.TL.1: Construct a spreadsheet in order to analyze multiple data sets, identify relationships, and facilitate data-based decision-making.
9.4.8.TL.2: Gather data and digitally represent information to communicate a real-world problem (e.g., MS-ESS3-4, 6.1.8.EconET.1, 6.1.8.CivicsPR.4).
9.4.8.TL.3: Select appropriate tools to organize and present information digitally.
9.4.8.TL.4: Synthesize and publish information about a local or global issue or event (e.g., MS-LS4-5, 6.1.8.CivicsPI.3).
9.4.8.TL.5: Compare the process and effectiveness of synchronous collaboration and asynchronous collaboration.
9.4.8.TL.6: Collaborate to develop and publish work that provides perspectives on a real-world problem.

STRATEGIES
- Groups Discussions
- Teacher Presentation
- Student Projects
- Interactive SMARTBoard Lessons
- Tutorials
- Online Practice using lesson specific websites
- Multimedia Presentations

EVALUATION
Assessments may include but are not limited to:
- Teacher Observations
- Class Participations
- Class Discussions

- Class Assignments
- Homework Assignments
- Student Notebooks
- Student Projects

Sixth Grade:
OVERVIEW:

Unit 1 Electric Vehicles

Electric vehicles have been developed and used for the last several decades, they are now becoming a practical form of transportation due to their inefficiency and expensive cost of production. However, in the future, they can play a part in reducing our reliance on fossil fuels. In Innovation and Design, students will use the Engineering and Design Process to build an electric vehicle that is able to travel down a track as fast as possible and carry a payload, or empty soda can. They will study gear ratios and try to find one that will provide maximum speed, and optimal power. Iterations and re-design will be necessary to increase speed and power of their car. They will also tackle the challenge of adding a photovoltaic cell to their chassis to power their vehicle in case their backup batteries fail. The goal of racing a car powered by a photovoltaic cell will be an exciting and challenging task.

Unit 2 Energy Efficient 3D House

Buildings account for about half of all of the energy consumed in the US. Today, architects are using computer-aided design software, like Google SketchUp to accelerate the design process and generate exceptional drawings in the context of a modest budget. This program allows clients to visualize green features such as solar panels, sustainable landscaping and building materials that will serve to produce a more sustainable world. Similar to real-world architects, students will use SketchUp to design a 3D energy efficient house drawn to scale. Students will research solar radiation, as well as photovoltaic cells and how they convert the sun's rays into electrical energy. With Google SketchUp, Google Earth and the Google 3D Warehouse, students can create contemporary eco-friendly homes and become even more inspired and educated about reducing their own ecological footprint.

ENDURING UNDERSTANDINGS

Students will:

- Select and use applications effectively and productively.
- Apply existing knowledge to generate new ideas, products, or processes.
- Communicate information and ideas to multiple audiences using a variety of media and formats. Contribute to project teams to produce original works or solve problems.
- Advocate and practice safe, legal, and responsible use of information and technology.
- Plan and manage activities to develop a solution or complete a project.
- Understand the relationships among technologies and the connections between technology and other fields of study. Understand the application of engineering design.
- The role of troubleshooting, research and development, invention and innovation and experimentation in problem solving.
- Apply the engineering design process.

ESSENTIAL QUESTIONS

Unit 1 Electric Vehicles

- What are the best design materials for strength and shape of a vehicle?
- How do batteries work and do different size batteries produce different amounts of electricity?
- What is the purpose of soldering and how is it done?
- What is aerodynamics and how does it affect a vehicle?
- What gear and how does it work?
- What is a torque vs speed ratio and how does it operate the way gears operate?
- How does weight affect the speed of a vehicle on various terrain?

- How can a photovoltaic cell be positioned to collect maximum sunlight and produce optimal voltage.

Unit 2 Energy Efficient 3D House

- What is the process for using computer aided design in a design solution?
- What are square feet and how is it calculated?
- What is passive solar heating?
- In what cardinal direction should a building be facing to harness optimal energy from the Sun?

REQUIRED RESOURCES

- Computer with internet connection(www.fueleconomy.gov)
- Solar Ray Catcher Kit from Pitsco

SCOPE AND SEQUENCE

Unit 1 Electric Vehicles (25 days)

- Environmental Education and fuel economy lesson.
- Basic of Design lesson.
- Battery Power lesson.
- Aerodynamics lesson.
- Introduction to gears.
- Prototyping and construction.
- English System of measurement lesson.
- Overview of the project. Construct a car that can travel in a straight path and travel as fast as possible.
- Study gears and understand the difference between a power ratio and a speed ratio.
- Construct the car.
    - o Draw, measure, cut, sand, and hot glue the axle assembly and motor to chassis.
    - o Solder the double A battery holder.
    - o Test and evaluate the car.
    - o Redesign and modify
    - o Complete the speed and voltage data sheet.
- Determine an angle that will allow a solar panel to collect the most direct sunlight.
    - Interpret this by looking at the solar panels shadow in addition to using a multimeter and measuring the DC voltage.
- Calculate the speed of their car by using multiple units of measurement.
    - o Human dimensions(i.e. what is a pace)
    - o English system of measurement (ie. feet per second to miles per hour)

Unit 2 Energy Efficient 3D House (12 days)

- Explain and demonstrate the process of creating isometric, auxiliary, floor plans, section views and site plans.
- Generate a floor plan drawing of the I&D classroom to scale.
- Identify how many square feet are in their house and understand how that number is calculated.
- Build a three-dimensional home to scale by inputting length, width and height dimensions.
- Apply the appropriate material to their home that will make it as energy efficient as possible.
- Determine where south will be located and then place as many windows as possible to collect passive solar energy.
- Identify, design and place an additional item that will make their house greener. (garden, clothesline, rain garden)
- Learn about and design a rain(water retention) barrel. They provide financial and ecological advantages by conserving water , reducing stream erosion by easing the volume of runoff during storms. Additionally, they reduce pollutants accumulated from roof surfaces.
- Design and place a minimum of 1 additional item on the exterior or their home to scale. (shed, table and chairs, swing set)

Seventh Grade:

OVERVIEW

This unit will provide students with a powerful understanding of the tradition of Greek and Roman architecture, and its influence on architecture in America and around the world. Students will be using a sketch-based 3D-modeling program called Google Sketch-Up. It offers a suite of powerful drawing tools that will allow students to design columns and arches before drawing formal architecture such as temples, amphitheaters, and basilicas or utilitarian buildings such as bridges and aqueducts. Students will then take on the role of an architect as they design their own buildings and then develop a digital 3-D model of it. When students finish designing their model, they can save and print it, or share them with others by posting them to the 3-D Warehouse, where it can be seen on a real map in Google Earth.

RATIONAL

Unit 1 Earthquake Towers

Engineers have been trying to understand the effects of earthquakes on structures for years. Such as how and why they cause such tremendous damage to structures. Working together, scientists and engineers are looking for ways to construct buildings that will withstand earthquakes. Like engineers, students will design and build a model structure out of balsa wood that will withstand the stress of a simulated earthquake. The activity is to simulate a 20-story, 200-foot high building. They will be testing their towers using a Programmable Earthquake Tremor Table. Students will analyze the effects of various loads and observe the forces that will shake their structure until it collapses.

Unit 2 Siege Machines

Siege engines were built as an ancient invention to bring an enemy to its breaking point, but in the modern world, they brought a great deal of delight. Catapults and trebuchets were once used to destroy castle walls, ruin enemy lines, or to throw projectiles inside a castle from an enemy ship. Today, these devices are loved for ingenuity in science and math. These big guns of siege warfare are built for entertainment, but they also do a tremendous job of enhancing math, history, physics, engineering, and problem-solving to young minds. Students will design, build, test, and modify scaled down versions of this powerful machine; meanwhile following pre-established criteria and constraints.

ENDURING UNDERSTANDINGS

Students will:

- Select and use applications effectively and productively.
- Apply existing knowledge to generate new ideas, products, or processes.
- Communicate information and ideas to multiple audiences using a variety of media and formats.
- Contribute to project teams to produce original works or solve problems.
- Advocate and practice safe, legal, and responsible use of information and technology.
- Plan and manage activities to develop a solution or complete a project.
- The relationships among technologies and the connections between technology and other fields of study.
- The influence of technology on history.
- The application of engineering design.
- The role of troubleshooting, research and development, invention and innovation and experimentation in problem-solving.
- Apply the design process.

ESSENTIAL QUESTIONS

Unit 1 Earthquake Towers

- What factors cause tremendous damage to structures during earthquakes?
- What is a frequency, and how are objects of various heights affected by different frequencies?
- When building an earthquake resistant structure, what components of a design are essential?

- What part of a structure should be flexible, and what part rigid, to best support the building during an earthquake?

Unit 2 Siege Machines

- What was a siege machine and how do they work?
- What were the most common types of siege machines?
- Why were siege machines valuable to use during Ancient times?
- What purpose does building these powerful machines serve today?

REQUIRED RESOURCES

- Computer with internet connection
- Catapult kit and Earthquake Engineering kit from Pitsco

SCOPE AND SEQUENCE

Unit 1 Earthquake Towers (20 days)

- Structures Lab PBS Webquest on forces, loads, materials, and shapes. (1 day)
- Introduction and notes on earthquakes and seismic waves. (½ day)
- Seismic waves lab/ activity. (1 day)
- Earthquake Engineering lab (1 day)
- Observe Harmonic Highrise and draw concept sketches. (1 day)
- From groups and create a 1 story prototype of a proposed design (2 days)
- Add live load, then test and evaluate and prototype (1 day)
- Draw 5 story working drawing with a 1 to 1 scale on graph paper. (2 days)
- Use a timber tester and measure balsa wood flexibility. (1 day)
- Measure, mark, cut, glue and pin columns and bracing of towers first 2 sides. (3-4 days)
- Stand up and glue floor plates of the first 2 sides of the tower (2 days)
- Measure, mark, cut, glue and pin columns and bracing of towers 3rd and 4th side. (3-4 days)
- Create a presentation on design and add mass plates to tower (1 day)
- Test and evaluate the structure. (1 day)

Unit 2 Siege Machines (14 days)

- Introduction and notes on simple machines, levers and siege machines. (1 day)
- Introduction to Physics Illustrator. (1 day)
- Build a trebuchet in Physics Illustrator. (1 day)
- Compare and contrast trebuchets to tension powered catapults. (½ day)
- Assemble and glue a tension powered catapult. (1 ½ days)
- Testing tension powered catapult experiment. (1 day)
- Compare and contrast tension to torsion powered catapults. (½ day)
- Build, test and evaluate torsion powered catapult. (2 days)
- Modify catapult for Ultimate Catapult Challenge. (2 days)
- Complete Catapult Challenge (accuracy to a random target, longest throw, and battle) (1 ½ days)
- Review and Summary (1 day)
- Assessment (1 day)

Eighth Grade:
OVERVIEW

This unit offers many new and unusual concepts and challenges to 8th graders as they design an aerodynamic dragster and race it down a level track. The goal of this unit is to provide a platform for students to apply concepts learned in physics and math in a real world setting. Students will also learn new skills and techniques used in the design process. Students will use 21st Century

Skills such as compromise and collaboration to carry out various tasks throughout the project.

Students will also complete a unit where they will take an idea from brainstorming to sketching, then to building a computer programmed robot which will complete multiple tasks. Using robots in education will help students grasp STEM concepts while emphasizing ingenuity, teamwork, and problem-solving skills. Students will design real-life apparatuses and use imagination, reason, and investigative skills to meet challenges that faced our nation in the 19th century all while learning essential science, technology, engineering, and math concepts.

RATIONAL

<u>Unit 1 CO2 Dragsters</u>

One of the most important considerations automobile engineers focus on when designing a vehicle is aerodynamics. The more aerodynamic a vehicle is, the better the car will move through the air. Students will learn and relate concepts from physics and math to a "real world" situation.

Students also use the engineering design process to learn about the relationship between friction, drag, and weight. Students must complete all design phases to build a successful dragster, and follow the specifications or limitations provided by the instructor. They will collaborate in groups to design a dragster that will have a low drag when placed in a wind tunnel and a high speed when raced on a track. Since the construction of the vehicle is not a linear process, revisions are encouraged and expected; this helps students realize the importance of analyzing and modifying a design to achieve success. Testing and analyzing the results are a key component in any technology or science lesson. Students will be able to discover the strengths and weaknesses in their design by measuring their dragsters weight, aerodynamic resistance, and rolling friction.

<u>Unit 2 Robotics</u>

The students' objective is to develop, build, and program a working robot to complete predesigned tasks on a course. Students will use various materials such as brackets, mounts, tubing, hubs, servos, motors, wheels, gears, batteries, connectors, and drive trains. Students will be working collaboratively to construct a working robot capable of moving, pushing, pulling and picking up an object. The robots will compete with others built in the class according to prearranged guidelines.

The robotics-based challenge, although a competition, will be designed as a "game" with a very practical goal. Students will work in teams to create the best robotics solution possible to complete the challenge. Students must use their brains and their hands to compete and find ways to design, build, and program robots from a standard set of parts. Teams will propose and test the theory, prototype examples, and program their robots. Joint teamwork, group problem solving, as well as the ability to meet deadlines, are all hallmarks of successful teams.

ENDURING UNDERSTANDINGS

<u>Unit 1 CO2 Dragsters</u>

- The intention of design is to construct something that functionally works and has a pleasant appearance.
- Craftsmanship relates being aware of limitations and paying attention to detail during the construction of a product. Craftsmanship influences how a car looks as well as how well it functions.
- Examining the effect the shape a car has can lead to improved aerodynamic design and better fuel economy.
- Aerodynamics is the study of how solid objects replace fluid air and other gasses. Cars and airplanes must be designed with rounded edges to reduce drag and increase efficiency.
- To understand how to achieve the speed you must explore the relationship between force, mass, and acceleration.
- Any task no matter how complex, simple, or basic must be done in an ordered sequence.

<u>Unit 2 Robotics</u>

- Achieving success with programming requires research, planning, testing and modifying.
- Understand the limitations of sensors and how they acquire information from the external world.

- Imagination, reason, and investigative skills have always been necessary for meeting challenges.
- Learning of science, technology, engineering, and math concepts can be integrated.

ESSENTIAL QUESTIONS

CO2 Dragsters

- What are the components of design (functionality & aesthetics) and why are they important to keep in mind as you are making a product?
- What is craftsmanship, what is its purpose and how does it affect the design of a car?
- How is drag determined, and how can it be reduced?
- What is aerodynamics, and how does it affect a vehicle in motion?
- How do you achieve speed? How do forces (inertia, thrust, friction) play a role on a vehicle?

Robotics

- What are robots and how can they be useful?
- What place do robots serve in our world?
- How can autonomous robots be designed to perform manual and repetitive tasks, at home and in the workforce?
- Why are flowcharts essential in robotic engineering and programming?

REQUIRED RESOURCES

- Basswood Dragster Blanks
- Pitsco Free Hand Foam Cutter
- Wind Tunnel
- Fog Maestro wind flow visualization
- Roll test ramp
- Race system
- Lego Mindstorms Education EV3 kit
- EV3 Programming software
- Ozobots

SCOPE AND SEQUENCE

CO2 Dragsters- (25 days)

- Engineering Design Process lesson (1-2 days)
- Physics Illustrator Car activity (2 days)
- Introduction, notes, and experiments (3 days)
- Group planning preparation (2 days)
- Architects design sketch (2 days)
- Prototype construction (2 days)
- Cutting dragster blank (4 days)
- Writing and shooting commercial for sponsor(2-3 days)
- Sanding dragster (1-2 days)
- Painting dragster (2 days)
- Testing dragster- wheel spin, wheel alignment, weight, wind tunnel (1-2 days)
- Racing dragster (1-2 days)
- Evaluation and Conclusion (1 day)

Robotics (20 days)

- Introduction to Westward Expansion(2 days)
- Introduction to Robots(1-2 days)

- Exploration with Ozobots (2 days)
- Basic chassis construction(1-2 days)
- Programming and experimenting extensions sensors (4 days)
  - Rotation
  - Ultrasonic
  - Color/light
  - Gyro
  - Touch
- Group planning and preparation(1-2 days)
- Completion of Challenge(3-4 days)
- Evaluation and Conclusion(1 day)