WISELearn Resources

Career Academy Teacher Externship Program

Title: Silly Putty Press

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Externship Business: [Walker Forge]

Overview / Description:

This investigation has students construct a simple press using Lego Mindstorms robotics kits (or equivalent robotics system) to model the forging process. In this inquiry lesson, students will determine their own designs and employ their robotics constructing and programming skills. The end result is a pressed piece of of silly putty that must be inserted into the press, impacted and removed from the press.

Subject(s):

Math, Science, Technology

Grade Level(s):

Grades 6-8 (could also be used at the high school level)

Learning goals/objectives:

After completing this activity, students should be able to:

- Be able to construct a moderately complicated design of Legos from their own design.
- Use 2-3 motors in their design to move the Silly Putty.
- Use a sensor to detect the presence of the Silly Putty before pressing (more advanced students)
- Program the robot to time the process correctly and move the motors at the correct rate and distance.
- Calculate the assembly line rate and devise solutions to accelerate the process.
- Compare designs to other groups and determine the best engineered solutions.

Type of Activity (check all that apply):

✓ Individual
✓ Small Group
■ Whole Class

Teaching Strategies (check all that apply or include new strategies)**:**

- ✓ Discussion
- ✓ Partner work
- ✓ Use of Technology
- ■ Role Playing
- ✓ Simulation
- ✓ Performance Assessment

Content Standards

Wisconsin Standards for Science

Crosscutting Concepts

SCI.CC2.m Students classify relationships as causal or correlational, and recognize correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be explained using probability.

SCI.CC4.m Students understand systems may interact with other systems: they may have sub-systems and be a part of larger complex systems. They use models to represent systems and their interactions—such as inputs, processes, and outputs—and energy, matter, and information flows within systems. They also learn that models are limited in that they only represent certain aspects of the system under study.

Science and Engineering Practices

SCI.SEP1.A.m Students ask questions to specify relationships between variables and clarify arguments and models. This includes the following: Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify or seek additional information. Ask questions to clarify or refine a model, an explanation, or an engineering problem.

SCI.SEP1.B.m Students define a design problem that can be solved through the development of an object, tool, process, or system, and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.

SCI.SEP2.A.m Students develop, use, and revise models to describe, test, and predict more abstract phenomena and design systems. This includes the following: Evaluate limitations of a model for a proposed object or tool. Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed.

SCI.SEP5.A.m Students identify patterns in large data sets and use mathematical concepts to support explanations and arguments. This includes the following: Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. Use mathematical representations to describe and support scientific conclusions and design solutions. Create algorithms (a series of ordered steps) to solve a problem. Apply mathematical concepts and processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems. Use digital tools and mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.

SCI.SEP6.B.m Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system. Undertake a design project, engaging in the design cycle, to construct and implement a solution that meets specific design criteria and constraints. Optimize performance of a design by prioritizing criteria, making trade-offs.

Engineering, Technology, and the Application of Science

SCI.ETS1.B.m A solution needs to be tested and then modified on the basis of the test results in order to improve it.

SCI.ETS1.C.m Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.

<u>Common Core Math:</u>

Measurement and Data

CCSS.MATH.CONTENT.5.MD.A.1 - Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.

CCSS.MATH.CONTENT.5.MD.B.2 - Make a line plot to display a data set of measurements in fractions of a unit (1/2, 1/4, 1/8). Use operations on fractions for this grade to solve problems involving information presented in line plots. For example, given different measurements of liquid in identical beakers, find the amount of liquid each beaker would contain if the total amount in all the beakers were redistributed equally

CCSS.MATH.CONTENT.5.MD.C3 - Recognize volume as an attribute of solid figures and understand concepts of volume measurement.

CCSS.MATH.CONTENT.5.MD.C.5 - Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume.

Geometry

CCSS.MATH.CONTENT.7.G.A.1 -Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

CCSS.MATH.CONTENT.7.G.A.2 - Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle.

<u>Length of Time and length of class periods:</u>

A minimum of five 45 minute class periods, depending on prior knowledge for the low and high end of time.

Materials List (linked if online resource please):

- Lego Mindstorms Robotics kits (NXT or EV3). VEX or other robotics systems could work equally as well.
- Ruler, calculator
- Computer and programming software
- Silly Putty

Directions (Step-by-Step):

NOTE: This lesson plan assumes that the students are already familiar with the Lego robot system or other similar robotic system. They have prior knowledge about the works of motor and sensor systems and programming language.

Day 1: Introduce the project by showing a video clip of a metal forge at work. If you don't have your own video of the process, you can use a YouTube clip such as https://youtu.be/tEF2erBBVZ4. Explain the background of how a forging press works to shape a piece of hot steel. Inform students that they will be simulating this process by using Lego construction, and the press will be shaping a piece of silly putty. The constraints on the system are as follows:

- One Lego "Brick" microprocessor, and no more than four motors may be used.
- More advanced classes should also incorporate a sensor system to engage the stages of the motors (this could be a touch, light or ultrasonic sensor).
- Only Legos may be used in the construction.
- No other items (string, wood sticks, etc.) may be used.
- Silly Putty Press Rubric

Instruct students of the basics of the engineering task. Silly putty will be placed on a Lego tray. The tray will be picked up by the first motor arm/claw/forklift. The tray then must be moved under the forging press. The press then comes down and creates an impression on the surface of the silly putty. The forge next raises back up and the tray is moved out from underneath. In a more advanced class, there can be more trays of silly putty so the system needs continual reloading. A reloading setup can then also allow the students to calculate the production rate or throughput.

Day 2: Prior to lesson, determine if this is going to be done individually or in small groups. This depends on your preferences as well as the number of robots available. There are advantages and disadvantages to singular and groups.

Divide the students up and instruct each to brainstorm ideas for solving this engineering problem. Hand out grid paper to have students start some rough blueprint ideations. Have students share their ideas with each other or to the entire class. Discuss the possible issues, constraints and variables at work in this system.

Day 3: Start by having the student groups select a plan and move on to prototyping. This will be some quick builds of Lego framework to establish the structure and see if the idea is worth pursuing. If the idea seems to work in their opinion, then they should take their rough model to the instructor for approval. If the idea seems workable to the instructor, they may continue on it to make their final model. If the instructor has the foresight to see that the idea is needing refining or a complete scrapping, then guidance should be provided.

Day 4-5. During this time, students build and iterate their design. Once the framing structure is in place, then the motors need to adjusted for time, speed, or rotation. The motors should have an arm, claw, lift, or other mechanism designed by the students in order to move the tray holding the silly putty. Depending on the age and skill of the students, this may take more class periods to complete.

Day 6+: Students have their designs demonstrated to the class. Discussion with the class should be had to explain how they came to their solution. More advanced classes should also explain the use of a sensor system to regulate the activation of the motors in the sequence.

Wrap-Up:

Each group uses an iPad or similar device to take a short video clip of the Lego press at work. The video can then be shared to the school's social media page or other methods of sharing classroom work to a greater audience.

Formative/Summative Assessment:

- Formative assessments can be in reviewing the measurements taken during practice, checking the blueprint design, and assessing their rough model before allowing them to continue on with the design process. Checks can also be made in the computer programming for the system, by having the students explain the process and how each programming step is figured out.

- Summative assessment is the completion of the design into a working system that creates an impression in the silly putty. The rubric is below.

Extension Activity for differentiation:

- This activity could be extended to more difficult parts that are more complex in their programming and set up.
- The setup could require the use of additional sensors, as well as the repetition of the pressing process.
- Mathematical calculations could be extended to require the calculation of distance per motor rotation, as well as throughput speed calculations.
- Students could try out different sensors to see which type of setup works the best.
- An industry expert in forging could visit the class to discuss forging before or give feedback on forging systems at the end of the process.

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Silly Putty Press Rubric

Criteria	Proficient (85-100)	Average (70-85)	Poor (<70)	Student's score
Student's setup of the Lego assembly	Student is able to use the Legos in an inventive and creative way to accomplish the problem. The design is structurally sound, reliable and precise.	Student can use the Legos to successfully complete the problem. However the design may not be the most elegant or reliable solution. The press may not work correctly every time.	Student's use of the Legos produced either an incomplete or malfunctioning design.	
Student's Programming of the Unit	Student's design is programmed using efficient programming language that is concise and optimal for the arrangement of the structure. Sensors are used effectively where required.	Students programming is simple but works to accomplish the task. The program is not the most efficient programming possible for the circumstance.	Student's program is not able to accomplish the task, or accomplishes it with manual assistance. The program does not allow for more than one press without a restart.	

Comments: