Transformation 2013 Design Challenge Planning Form Guide

Design Challenge Title: Butler Robot

Teacher(s): Jennifer Lane

School: Taylor High School

Subject: IPC/Physics/Robotics

Abstract: Students are challenged to design, create, and program a Butler Robot that holds an assignment securely while maneuvering through a set path to the teacher's desk and places an assignment into the correct bin (homework, class work, quiz bins). Through this challenge, students investigate the laws governing motion.

MEETING THE NEEDS
OF STEM EDUCATION
THROUGH DESIGN CHALLENGES

Begin with the End in Mind

The theme or "big ideas" for this design challenge:

You are an engineer at a major design firm in Austin and you and your team has been commissioned to design a robot to help high school students in IPC class take their finished work from their desk to the correct bin at their teacher's desk.

TEKS/SEs that students will learn in the design challenge:

IPC 2 The student is expected to:
(A) plan and implement investigative procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology;
(B) collect data and make measurements with precision;
(C) organize, analyze, evaluate, make inferences, and predict trends from data; and
(D) communicate valid conclusions.

IPC 4 The student is expected to:
(A) calculate speed, momentum, acceleration, work, and power in systems such as in the human body, moving toys, and machines

Physics 4 The student knows the laws governing motion. The student is expected to:

(A) generate and interpret graphs describing motion including the use of real-time technology;
(B) analyze examples of uniform and accelerated motion including linear, ~~projectile, and circular~~;
(C) demonstrate the effects of forces on the motion of objects;
(E) identify and describe motion relative to different frames of reference

Key performance indicators students will develop in this design challenge:

Students collect data and make measurements. Then take that data analyze it and make inferences in order to design their robot. The students will be able to investigate how Newton's laws will be affecting the design of their robot. The students will investigate mechanical advantage and efficiency of various simple machines.

21st century skills that students will practice in this design challenge:
www.21stcenturyskills.org

1. Demonstrating ability to work effectively with diverse teams
2. Exercising flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal
3. Understanding the interconnections among systems

STEM career connections and real world applications of content learned in this design challenge:

Robotics and programming

The Design Challenge

You are an engineer at a major design firm in Austin and you have been commissioned to design a Butler Robot to help high school students in IPC class take their finished work from their desk to the correct bin at their teacher's desk. You will design, create, and program a Butler Robot that holds an assignment securely while maneuvering through the path and up the ramp onto the teacher's desk, and then places the assignment into the correct bin (homework, class work, quiz bins). The Butler Robot should complete this task as quickly as possible.

Map the Design Challenge

Performance Indicators	Already Learned	Taught before the project	Taught during the project
1. Plan and implement investigative procedures such as asking questions and formulating testable hypotheses.	✓		
2. Plan and implement investigative procedures such as selecting equipment and technology.		✓	✓
3. Collect the data and make measurements with precision in order to create a small data table.			✓
4. Collect the data and make measurements with precision in order to create a plot of the distance traveled by your robot as a function of rotations of your motors.		✓	✓
5. Collect the data and make measurements with precision in order to measure the path in the classroom.		✓	
6. Organize, analyze, evaluate, make inferences, and predict trends from data in order to properly program the robots to complete the set tasks.		✓	✓
7. Communicate valid conclusions with their group members in order to complete the task.		✓	✓
8. Calculate speed, acceleration, and power for the Butler Robot.		✓	
9. Investigate and describe applications of Newton's laws in how they affect aspects of the robot's movements.		✓	✓

5E Lesson Plan

Design Challenge Title: The Butler Robot
TEKS/TAKS objectives: IPC 2ABCD, 4A; Physics 4ABCE
Engage Activity

http://www.foxnews.com/story/0,2933,183193,00.html

Read the story "Japanese Working on Robot Butler", found at the link provided, to the students.

Ask the students to create a one paragraph journal response to the following prompt:

What would you want a Butler Robot to do for you?

Facilitate a share session of the student responses and list the students' responses on chart paper.

After students have expressed their ideas, state that you would like them to have a Butler Robot that would turn their assignments in on time to the appropriate bin (show them the bins at your desk); that you are tired of the excuse "I forgot to turn it in". Furthermore, you've spoken with several teachers around the world that experience the same situation. Due to this demand (introduce the design challenge to your students):

As an engineer at a major design firm in Austin, and you have been commissioned to design a Butler Robot to help high school students take their finished work from their desk to the correct bin at their teacher's desk. You will design, create, and program a Butler Robot that holds an assignment securely while maneuvering through the path and up the ramp onto the teacher's desk, and then places the assignment into the correct bin (homework, class work, quiz bins). The Butler Robot should complete this task as quickly as possible.

Engage Activity Products and Artifacts

Journal Entry

Engage Activity Materials/Equipment

Map of Butler Robot path (marked with painter's tape) in classroom

Engage Activity Resources

http://butlerrobot.com/

http://forums.trossenrobotics.com/showthread.php?t=1978
http://www.instructables.com/id/Build-Your-Own-Butler-Robot/

Explore Activity

Hands-on exploration of the mechanics of how things work and move:

1. Provide and display devices, toys, kitchen appliances, power tools, etc on a table at the front of the classroom.
2. Each student chooses one item from those provided and returns to seat with item.
3. Allow students 5-10 minutes to examine and attempt to describe how the device functions or performs.
4. Using Round Robin format, each student describes to the class his/her chosen device using appropriate terminology.
5. All students should create a chart in their journals with the headings: "device", the "key terms" and a "description" of how each others' devices function.

Targeted Terms: speed, momentum, acceleration, work, and power

Untargeted Terms: force, potential energy, kinetic energy, mechanical energy, gears (rack and pinion, crown, worm, spur, beveled), levers, tension, effort, resistance, mechanical advantage, switch, coil or compression spring, torque, motor, actuator, feedback mechanism, etc.

The role of the teacher is to facilitate students' use of the proper terminology as the students describe how each device functions and interject terms as necessary. Additionally, to focus on the vocabulary indicated by the TESK addressed.

Explore Activity Products and Artifacts

Journal Entry: Device Table

Explore Activity Materials/Equipment

toys, appliances, devices

Explore Activity Resources

www.toyjoy.com
www.howstuffworks.com

Explain Activity

Guided Discussion:

Continue discussion of the way the devices work and introduce the concept of algorithms and flow charts. Choose one device and write the control algorithm and demonstrate visually using a flow chart. Refer to ControlsNotes.doc.

Assign students homework: Create a control algorithm of a device or process of choice.

Explain Activity Products and Artifacts

- Flow chart (control algorithm) of device created by entire class.
- Flow chart (control algorithm) of device operation or process chosen by student (homework).

Explain Activity Materials/Equipment

chart paper or whiteboard, markers for group flow chart

Explain Activity Resources

ControlsNotes.doc

Explore Activity

Construction using Lego Mindstorms kits

1. Introduce Lego Mindstorm hardware kits by showing construction possibilities (pictures of examples or actual builds) from the kits.
2. Organize students into pairs.
3. Distribute a Lego Mindstorm kit to each pair.

In pairs, students will build device from possibilities of 3-wheeler, 4-wheeler, treaded vehicle

Explore Activity Products and Artifacts

Completed build

Explore Activity Materials/Equipment

Lego Education Mindstorm NXT (white box), Education Resource set (blue box).
Instructions for construction of each of the builds (3-wheeler, 4-wheeler, treaded vehicle)

Explore Activity Resources

www.nxtprograms.com

Explain Activity

Guided NXT programming (You can skip this activity if students already have familiarity with NXT programming)

1. Students will work individually at a computer with the NXT software.
2. Referencing the algorithm flow chart process, walk through programming the operation of one of the builds in the previous activity using the NXT software by facilitating a discussion of the device's operation calling upon random students to participate in choosing next step of program (eventually involving all students).
3. Students follow along creating the programs to test on their devices.
4. Groups test programs on devices.

Explain Activity Products and Artifacts

Student generated NXT program for devices.
Test run of programs on devices.

Explain Activity Materials/Equipment

Laptop or desktop computers loaded with NXT software for each student, Lego Mindstorm builds from previous activity

Explain Activity Resources

www.nxtprograms.com

Explore Activity

Power and Speed Lab

To solve the Butler Robot Design Challenge, you will need to know how fast your vehicle travels for each motor power setting. In this laboratory, you will time your vehicle as it travels for one meter. You will use this data to graph the relationship between vehicle speed and power setting.

Procedure:

1. Lay out a straight track one meter long for your vehicle. Mark the starting line and finish line with masking tape.

2. Write a NXT program to drive your vehicle (use a move block) with a power setting of 10%. You might to have your vehicle make an alert sound (beep) to

indicate when it starts. With a stop watch, record the time it takes for the vehicle to travel one meter. Repeat this procedure two more times for a total of three trials. Record the data in a table, and compute the average time.

3. Repeat step 1 for power settings of 20% through 100% in 10% increments. Record three trials for each power setting and compute the averages.

4. Compute the speed of your vehicle in meters per second for each power setting and record on your data table.

5. Enter the data in a graphing calculator or Excel spreadsheet. The x-axis variable is the power setting, and the y-axis is the vehicle speed. Plot the relationship. Is it linear?

6. How can use this information in the design of you Butler Robot?

Explore Activity Products and Artifacts

Power and Speed Lab report

Explore Activity Materials/Equipment

Builds from previous activity, meter stick, masking tape, student journals, TAKS formula chart (speed = distance/time)

Explore Activity Resources

3-wheeler, 4-wheeler, treaded vehicle
www.nxtprograms.com

Explain Activity

Power/Speed Lab Debrief

Discuss with students the results of their lab activity.

Explain Activity Products and Artifacts

Power and Speed Lab report

Explain Activity Materials/Equipment

none

Explain Activity Resources

http://www.glenbrook.k12.il.us/gbssci/phys/Class/1DKin/U1L1d.html

Elaborate Activity

Students complete open ended design brief:

Design Challenge – Butler Robot

As an engineer at a major design firm in Austin, and you have been commissioned to design a Butler Robot to help high school students take their finished work from their desk to the correct bin at their teacher's desk. You will design, create, and program a Butler Robot that holds an assignment securely while maneuvering through the classroom and up the ramp onto the teacher's desk, and then places the assignment into the correct bin (homework, class work, quiz bins). The Butler Robot should complete this task as quickly as possible. A schematic of the classroom is shown in Figure 1.

(insert schematic of your classroom here)

Figure 1: Schematic of Classroom

In this lab, using the vehicle you have constructed, you will program the Butler Robot device to travel a path to the teacher's desk. Access to the desk is by way of a ramp.

The challenge will be completed in two phases:

1. Phase I: Negotiate through the classroom entirely by timing or motor control (number of rotations or number of degrees) to determine when to turn your vehicle. The Butler Robot will enter the classroom through the door and negotiate the path provided (marked with painter's tape) to get to the teacher's desk, travel up the ramp provided and deposit the assignment in the appropriate bin. You will be timed for this task.

   To complete this phase of the challenge, develop a procedure and / or flowchart to assist you in solving the challenge. You should also create a small data table and plot of the distance traveled by your mobility assistance chair as a function of the number of rotations of your motor(s). You should include at least three values for motor rotation, e.g., 5, 10, and 25 rotations. Plot the distance traveled by the chair as a function of the motor rotations, assuming a given (constant) power setting.

You can use this result to plan (e.g. with a procedure or flowchart) how you will negotiate the Butler Robot path.

2. Phase II: Negotiate through the classroom entirely under sensor control. Do not use timing or motor control (number of rotations or number of degrees) to determine when to turn your vehicle. The Butler Robot will enter the classroom through the door and negotiate the path (marked with painter's tape) provided to get to the teacher's desk, travel up the ramp provided and deposit the assignment in the appropriate bin. You will be timed for this task.

Scoring:

The challenge will be scored based on a rubric and 100 points possible per phase. A portion of the score for each phase will be assigned based on the team's ability to describe a systematic approach they used to solve the challenge (including procedures, flowcharts, or mathematical relationships or plots); observations and insights of the team regarding automation, mathematics principles, and science principles; and the creativity employed by the team. Be willing to discover interesting physical phenomena, opportunities for mathematics, and cooperative learning effects as you solve this challenge.

Elaborate Activity Products and Artifacts

Flow chart of the control algorithm.
Sketches of alternative concepts.
Concept models.
Blueprint
NXT Program
Hardware (physical or virtual prototype)

Elaborate Activity Materials/Equipment

Builds from previous activity, NXT software, Butler Robot path marked in classroom, Butler Robot design brief

Elaborate Activity Resources

Common Palette Refence Card document, LEGO hardware document

Evaluate Activity

Demonstration of integrated working prototype and presentation of how it was designed.

Evaluate Activity Products and Artifacts

Working prototype, Group Collaboration Evaluation, presentation

Evaluate Activity Materials/Equipment

none

Evaluate Activity Resources

Butler Robot Design Challenge Rubric

Rubrics

Butler Robot Design Challenge Rubric

Team: _____

	Does not meet expectations	*Meets few expectations*	*Meets most expectations*	*Meets all expectations*
Phase I: Timing/Motor Control	**(0)**	**(5)**	**(15)**	**(20)**
Butler Robot navigates path on the first attempt				
Rank in time (minimum time to turn in assignment)				
Design solution is based on systematic / predictable development (procedures, flow chart, mathematics results, science concepts) as communicated by the team				
Creative solution or solution approach (handles obstacles, vehicle modifications, programming approach, use of additional materials, etc.)				
Insights in mathematics, science, automation, and discovery of physical phenomena as evidenced by student presentation				
Phase II: Sensing Control	**(0)**	**(5)**	**(15)**	**(20)**
Butler Robot navigates path on the first attempt				
Rank in time (minimum time to turn in assignment)				
Design solution is based on systematic / predictable development (procedures, flow chart, mathematics results, science concepts) as communicated by the team				
Creative solution or solution approach (handles obstacles, vehicle modifications, programming approach, use of additional materials, etc.)				
Insights in mathematics, science, automation, and discovery of physical phenomena as evidenced by student presentation				

Total Score/200: _____%