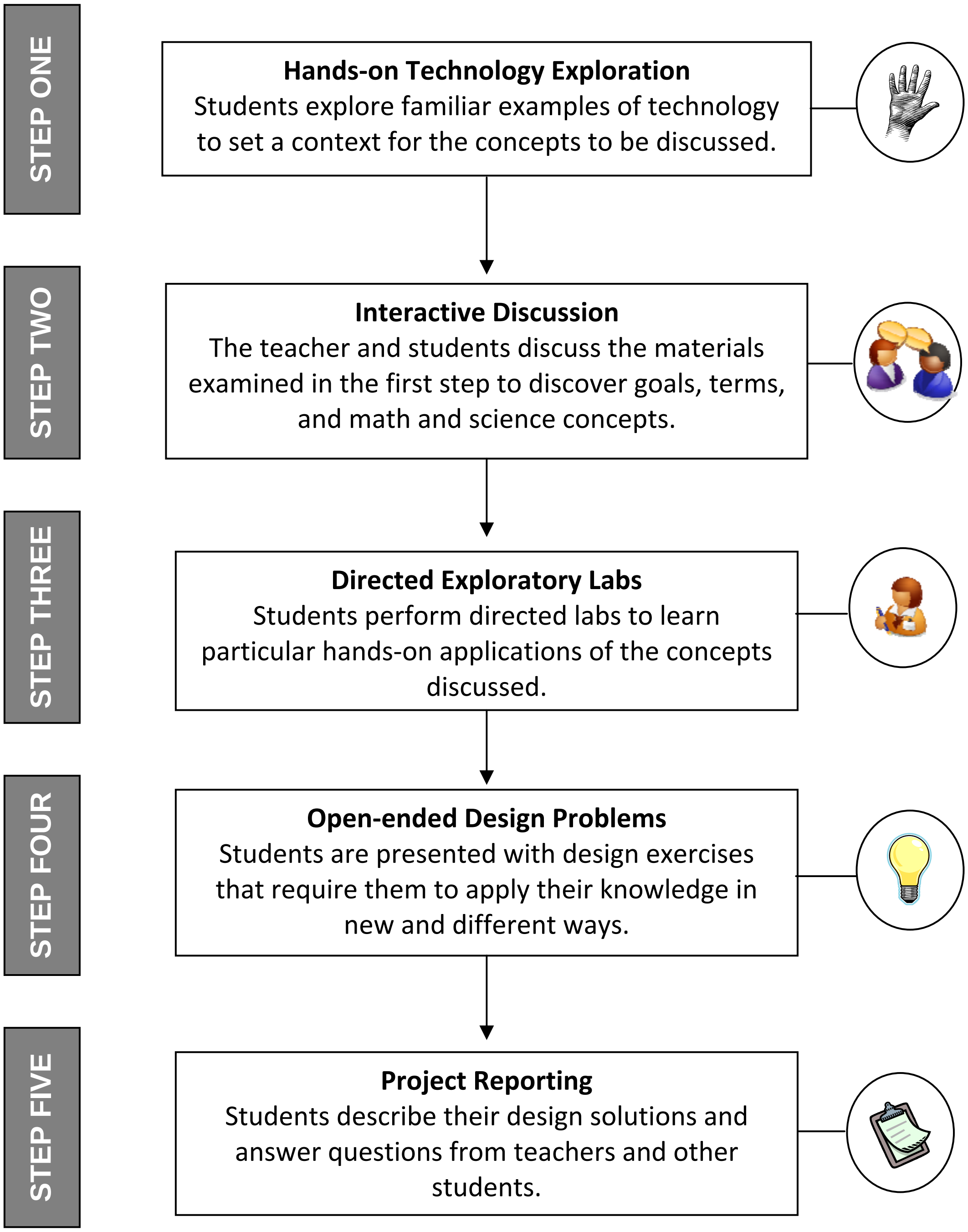
DTEACh
The University of Texas
Cockrell School of Engineering

Automation and Control Curriculum

Grades 3-5

The Five-Step DTEACh Teaching Model

The DTEACh teaching method, an effective model for engaging and educating students from Kindergarten through graduate school, comprises five steps.



Automation and Control

Student Outcomes:

- Students will explore everyday automatic systems and develop explanations for how they work.
- Students will identify control systems and differentiate between open and closed systems.
- Students will create flow charts of everyday tasks and automated devices to represent the flow through a control system.
- Students will design, build, and program robotic devices to complete design challenge.
- Students will research everyday automatic devices to identify and determine how the parts that make up the system work together. Students will create a visual aid explaining how the automatic devise works.

TEKS Objectives:

Science

- Collect information by observing and measuring. *(3.2B, 4.2B, 5.2B)**
- Analyze and interpret information to construct reasonable explanations from direct and indirect evidence. *(3.2C, 4.2C, 5.2C)**
- The student knows that a system is a collection of cycles, structures, and processes that interact. *(3.5, 4.5, 5.5)**

Math

- Identify the mathematics in everyday situations. *(3.14A, 4.14A, 5.14A)*
- Solve problems that incorporate understanding the problem, making a plan, carrying out the plan, and evaluating the solution for reasonableness. *(3.14B, 4.14B, 5.14B)*
- Explain and record observations using objects, words, pictures, numbers, and technology. *(3.15A, 4.15A, 5.15A)*
- Relate informal language to mathematical language and symbols. *(3.15B, 4.15B, 5.15B)*

Language Arts

- Speak appropriately to different audiences for different purposes and occasions. *(3.3)*
- Communicate clearly by putting thoughts and feelings into spoken words. *(3.4)*
- Generate questions and conducts research using information from various sources. *(3.12)*
- Use writing as a tool for learning and research. *(3.20)*
- Connect experiences, information, insights, and ideas with those of others through speaking and listening. *(4.4A, 5.5A)*
- Speak clearly and appropriately to different audiences for different purposes and occasions. *(4.5, 5.5)*
- Inquire and conduct research using a variety of sources. *(4.13, 5.13)*
- Write for a variety of audiences and purposes, and in a variety of forms. *(4.15, 5.15)*
- Use writing as a tool for learning and research. *(4.21, 5.21)*
- Produce visual images, messages, and meanings that communicate with others. *(4.25, 5.25)*

Technology

- The student uses a variety of strategies to acquire information from electronic resources, with appropriate supervision. *(3.4, 4.4, 5.4)*
- The student acquires electronic information in a variety of formats, with appropriate supervision. *(3.5, 4.5, 5.5)*
- The student uses appropriate computer-based productivity tools to create and modify solutions to problems. *(3.7, 4.7, 5.7)*
- The student uses research skills and electronic communication, with appropriate supervision, to create new knowledge. *(3.8, 4.8, 5.8)*

* Identifies TEKS that are tested on TAKS (Texas Assessment of Knowledge and Skills)

Vocabulary:

technology applying a systematic technique, method, or approach to solve a problem. Includes the use of materials, tools, techniques, and sources of power to make life easier, more productive, and more pleasant.

system a group of parts that work together as a unit.

control system Circuits that control the way a device operates

open loop A system in which a particular input produces a particular output

closed loop A system that checks what is happening at the output, and if necessary, changes what happens

feedback Involves the use of a sensor to detect changes tat ht output and to feed information back to the control device, which may modify the output.

input Something put into a system to achieve a result.

output The energy, power, or work produced by a system.

automation Making products under the control of computers and programmable controllers

sensor A device that receives and responds to a signal or stimulus

actuator A mechanical device used for moving or controlling a mechanism or system.

simple machine The basic machines that make up other machines.

lever A bar that moves on or around a fixed point.

pulley A simple machine made up of a rope or chain and a wheel around which the rope fits

gear A toothed machine part, such as a wheel or cylinder, that meshes with another toothed part to transmit motion or to change speed or direction.

inclined plane Flat surface with one end higher than the other

wedge A machine made up of two inclined planes placed back-to-back.

screw An inclined plan wrapped around a pole.

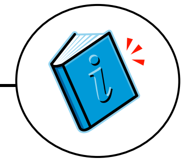
wheel and axle A simple machine made up of a large wheel attached to a smaller wheel or rod

force A push or a pull

algorithm a series of steps in a process that has a definite beginning and ending.

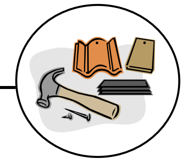
hardware The components necessary to implement an algorithm

<u>Background Information:</u>



Refer to the DTEACh *<u>2007NXT Teacher Training Materials</u>*, available online at
http://www.engr.utexas.edu/dteach/teachers/profdev/2007materialsnxt.cfm

<u>Materials:</u>



Everyday devices found around the school and home
Engineering Journal: *Automation, Control Systems, Flow Chart Template, Flow Chart Directions*
Construction paper, poster board

<u>Technology:</u>

Inspiration or Microsoft Word *flow chart template*

<u>Website Resources:</u>

Odd Machine
http://www.edheads.org/activities/odd_machine/index.htm

Simple Machines
http://www.edheads.org/activities/simple-machines/index.htm

Gadget Anatomy
http://www.mos.org/sln/Leonardo/GadgetAnatomy.html

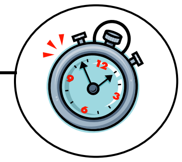
Goldburger to Go
http://pbskids.org/zoom/games/goldburgertogo/

How Stuff Works
http://www.howstuffowrks.com

<u>Literature Connections:</u>

<u>The New Way Things Work</u> by David Macaulay
<u>The Way Things Work</u> by David Macaulay and Neil Ardley
<u>The Way Things Work: The Complete Illustrated Guide to the Amazing World of Technology</u> by Chris Oxlade

Time:



Automation

- DTEACh 1: Hands-on Technology Exploration 45 minutes
- DTEACh 2: Interactive Discussion 30 minutes

Control

- Control Systems
  - DTEACh 1: Hands-on Technology Exploration 60 minutes
  - DTEACh 2: Interactive Discussion 30 minutes
  - DTEACh 5: Project Reporting 20 minutes
- Flow Charts
  - DTEACh 1: Hands-on Technology Exploration 60 minutes
  - DTEACh 2: Interactive Discussion 30 minutes

Evaluation and Extension

- Evaluation 90 minutes
- Extension time will vary

Introduction to LEGO MINDSTORMS Hardware

- DTEACh 3: Directed Exploratory Lab: *Building with LEGOS* 60 minutes
- DTEACh 4: Open ended Design Challenge: *Building a Can Push Vehicle* 90 minutes
- DTEACh 5: Project Reporting 30 minutes

Introduction to LEGO MINDSTORMS Software

- DTEACh 3: Directed Exploratory Labs: *Programming in NXT or RoboLab* 60 minutes
- DTEACh 4: Open-ended Design Challenge: *Programming a Can Push Vehicle* 90 minutes
- DTEACh 5: Project Reporting 30 minutes

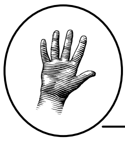
Next Steps in Building and Programming

- DTEACh 3: Directed Exploratory Lab: *Build and Program a Star Trek Door* 60 minutes
- DTEACh 4: Open-ended Design Challenge: *Three mid-level Design Challenges* 3 hours
  A Better Mouse Trap, Automatic Putt Returner, Mechanimals
- DTEACh 5: Project Reporting 60 minutes

More Design Challenges

- DTEACh 4: Open-ended Design Challenges time will vary
  - ◊ *Amusement Park Ride*
  - ◊ *Lunch Box Alarm*
  - ◊ *Dr. DeSoto's Dentist Chair*
  - ◊ *Silent Alarm Clock*
  - ◊ *Storytelling with Mechanimals*
  - ◊ *Soccer Ball Return*
  - ◊ *Automatic Soccer Goalie*
  - ◊ *Batting Practice*
  - ◊ *Catapults*
  - ◊ *Fishing Machine*
  - ◊ *Airport Security Screener*
  - ◊ *Pinball Machine*
- DTEACh 5: Project Reporting 60 minutes
- Student Evaluation Rubric 20 minutes

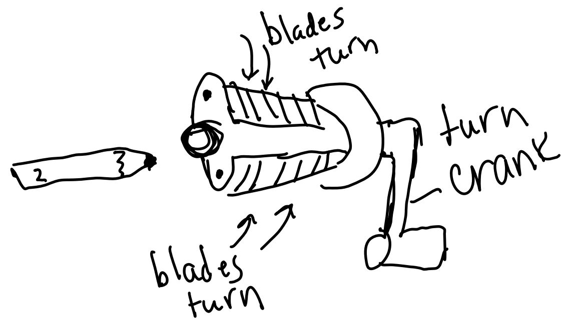
❖ Automation



Step One: Hands on Technology Exploration

1. Ask students to examine an example of everyday technology such as a manual pencil sharpener or a toy. Students may observe the parts inside the device by taking it apart.
    - Students will discuss how they think the device works. They will draw diagrams of the inside and outside of the object and write their explanations in their Engineering Journals.

en.wikipedia.org/wiki/Pencil_sharpener



2. Discuss:
    - As a class look at the inside of the device and identify the parts that make up the **system.** Construct an explanation for how the parts enable the system to work.
    - Students will share and compare their drawings.
    - Identify the **simple machines** that make up the device.
    - Construct an explanation for the term **technology**.

3. Divide students into small groups or allow them to work independently.

4. Each group or student will select an example of everyday technology. Students may bring their own examples or select from devices provided by the teacher.
    - Students will look inside their devices, identify the parts that make up the system and explain how the parts work together to make the system work.
    - Students will record drawings and explanations in their Engineering Journals.

Step Two: Interactive Discussion

1. Students will share their drawings and explanations of their device with the class.

2. Review terms such as **sensors**, **lever, screw, inclined plane, gear, pulley, wheel and axle,** and **force**. Students will add vocabulary to their Journals.

3. Use reference materials and online resources to discuss concepts further.

Engineering Journal
Automation

Draw what you observe inside and outside the automated device.

Record your results and conclusions:

1. Identify the parts that make up the device.

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2. Explain how you think the system works.

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3. Identify the simple machines that make up the device.

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4. What have you learned from this activity? Include new vocabulary terms you have learned.

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❖ Control: Control Systems

Step One: Hands-on Technology Exploration

1. Brainstorm other automatic devices that students use every day. Distinguish between mechanical and automatic.

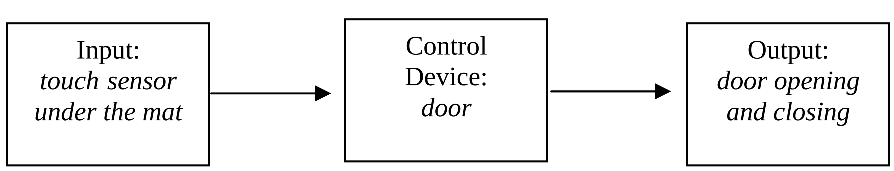
2. **Ask:**
   - **How does each of the systems work?**
   - **What makes the parts of a system work together?** Sequence of actions that must occur.

3. Ask students to explain how an automatic door at a grocery store works.
   - Use the term **sensor** to identify the device that senses people moving over the store entrance.
   - Identify moving over the entrance as the **input** that tells the door to open. The opening of the door is the **output**.

4. Act out an example of a control system.
   - Ask 2 students to stand in front of the classroom. Explain that they will stand next to each other to represent the automatic door at the grocery store.
   - Place a mat on the floor in front of the automatic door (students).
   - Ask the class what should happen when someone walks up and stands on the mat. The door should slide open because the sensor under the mat signals a motor to run. After a specific amount of time, the door will slide shut.
   - Ask a student to come stand on the mat. The students representing the automatic door will move apart to allow the student standing on the mat to pass. After a set amount of time, the students may move back into their original position to represent closing the door.

5. **Ask:**
   - **What set the control (door) in motion?** Stepping on the mat (input).
   - **What are we controlling?** Door (control)
   - **What is the outcome?** Motors opening and closing doors (output). Identify the **input** (standing on the mat) and the **output** (door opening and closing). Together the input and output make up a **control system**. In this control system a particular input produces a particular output. This is called an **open loop system**.

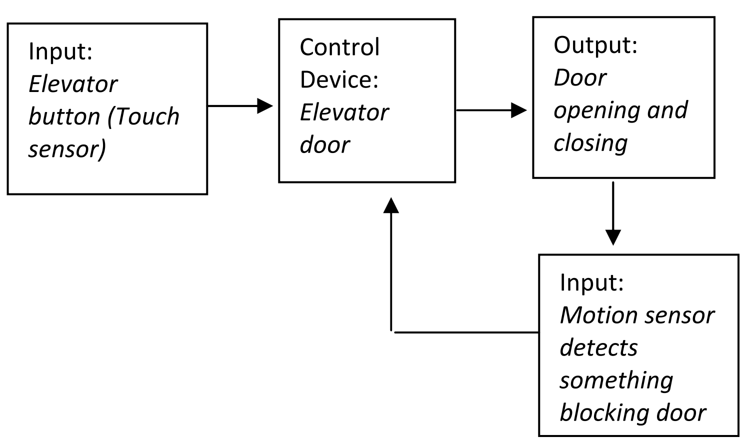
6. Draw a block diagram on the board to represent the control system. An open loop system is linear.



7. Brainstorm other examples of open looped systems such as typing on a keyboard, railroad crossing, elevator, garage door, automatic paper towel dispenser, automatic sink, toilet, automatic pencil sharpener, motion sensor, sprinkler system, car window.

8. Organize students into groups of two to create their own open loop system. Students must demonstrate and identify the *input*, *control device*, and *output* in their systems to the class. Students will record their control systems in their Engineering Journals.

9. Ask two students to come to the front of the room to act out a different type of control system.
    - The two students will stand together to form an elevator door. (control device).
    - A third student will stand in front of the elevator door and pretend to press a button (input). The students representing the elevator door (control device) will move apart so the student may pass. Once the elevator door is open (output), the students representing the elevator door will count up to two seconds and will then close.
    - Another student (input: sensor) will stand nearby to watch for anything that may move in the way of the door once it begins to close. The student (input: sensor) will continually communicate to the elevator door saying either, "Clear," or, "Stop," depending on whether someone is blocking the door.
    - Ask students from the class to take turns using the elevator. Each time the door opens students may move all the way through or may stop in the doorway of the elevator to prevent the door from shutting.
    - During each test, the student (input: sensor) must instruct the elevator door. If someone stops in the doorway the student (sensor) will say, "Stop." Once the passenger clears the door, the student (sensor) will say, "Clear," and the elevator door may close (output).
    - **Discuss:**
        - **Why does an elevator door stop moving once it senses something blocking it?**
        - **How is this situation different from the grocery store automatic door?**
    - Draw a block diagram on the board to represent the control system. Identify this as a **closed loop system**. Ask students to explain how closed loop system is different than the open loop system. Closed loop is not linear and is a system with **feedback**. The feedback involves the use of a sensor to detect a change at the output and feed information back to the control device, which may then adjust or change the output. In the elevator door example the student (input: sensor) was constantly checking whether someone was blocking the door, so the door could make adjustments.



10. Organize students into small groups to create their own closed loop system. Students must demonstrate and identify the *input, control device, output*, and *feedback* in their systems to the class. Students will record their control systems in their Engineering Journals.
    - Brainstorm ideas with students: alarm clock with snooze, thermostat, water level, refrigerator door alarm, spell check.

Step Two: Interactive Discussion:

1. Discuss the difference between open and closed loop systems. Compare the block diagrams. Review and construct explanations for terms: *input, control device, output, feedback, control system, open* and *closed loop.*

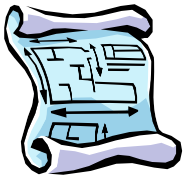
2. Brainstorm and list examples of open looped systems such as typing on a keyboard, automatic doors at the grocery store, automatic paper towel dispenser.

3. Brainstorm and list examples of closed looped systems: toilet, cruise control, thermostat.

Step Five: Project Reporting

1. Students will draw examples of open and closed loop systems in their Engineering Journals and then explain the difference between them.

2. Students may share their work with the class.



Engineering Journal
Control Systems

Draw a block diagram of an open loop system.

Draw a block diagram of a closed loop system.

Explain the difference between an open loop and closed loop control system.

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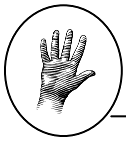
❖ Control: Flow Charts



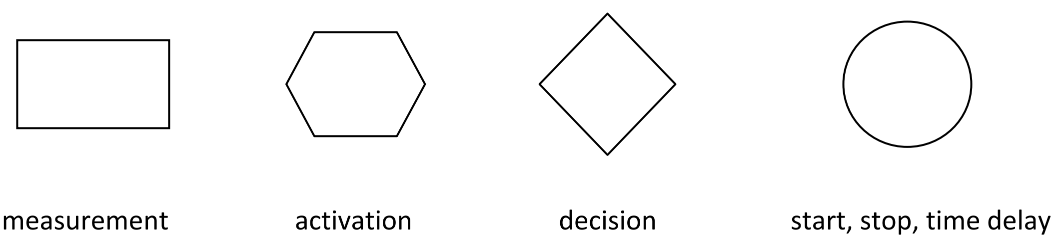
Step One: Hands-on Technology Exploration

1. Review the automated devices and control systems the students have studied do far. The open and closed loop systems students acted out were pretty simple. It will be important to have a method for writing the process of more complex control systems.

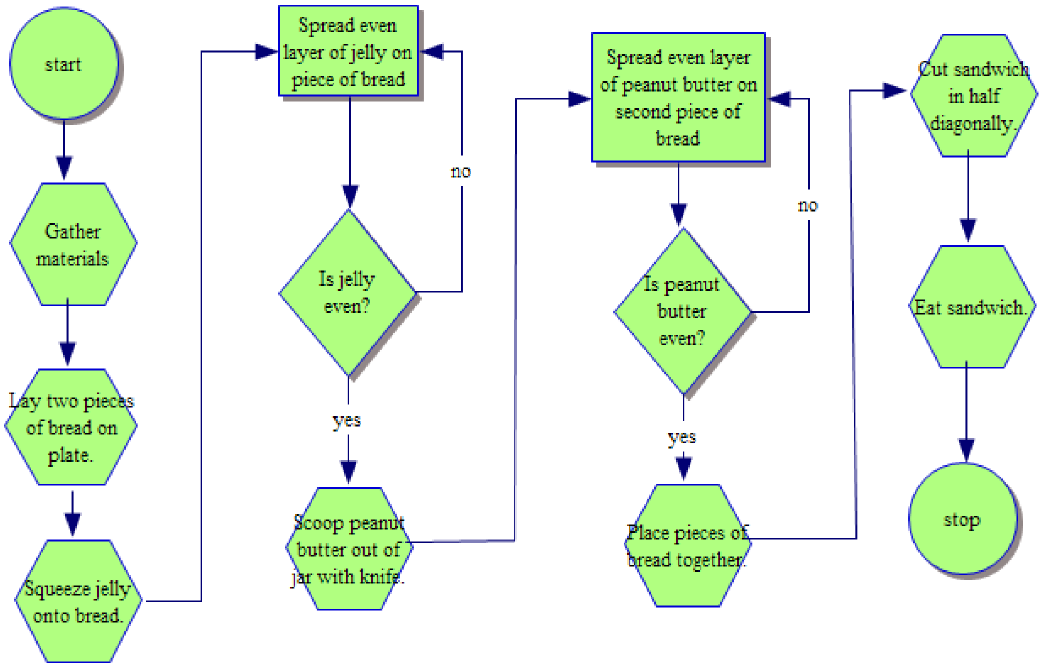
2. Introduce the term **flow chart**. Flow charts are another method for representing the flow through a control system. Flow charts show the functions of sensing, decision-making, and activation.

3. Select a task that all students will be familiar with such as making a sandwich. Ask students to list each step in the process. The class will create a flow chart to represent the steps necessary to making a sandwich.

4. Introduce the flow chart symbols students will use for their algorithms.



5. As students identify sequence of steps in making a sandwich, the teacher will create a flow chart on the board, overhead, or computer. Arrows connect the symbols to indicate the flow of the control system.



6. Ask if the flow chart for making sandwiches is an open or closed loop. Students should explain that the flow chart is a closed loop system because it includes feedback. The sandwich maker will readjust the peanut butter and jelly to match the specifications.

7. Identify the term **algorithm.** The flowchart is an algorithm because it shows the sequence in which the functions are performed from beginning to end. Ask students to identify math algorithms they routinely follow such as determining area and solving division and multiplication problems. Write examples on the board and discuss how the algorithms are affected by changing the sequences of the steps.

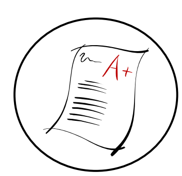
8. Brainstorm other tasks that follow a sequence of steps such as checking out a library book, making a snack, traveling to school, riding a bike, or recording a favorite TV program.

9. Students will work in pairs to create a flowchart of a task. If computers are not available students may cut out and trace the Flow chart templates on construction paper.

Step Two: Interactive Discussion:

1. Students will present their completed flow charts to the class and use appropriate terms as they explain their algorithms.

2. Select an example of an automated device. As a class create a flow chart showing how the device works. Students should understand that the flow chart is a representation of the sequence of the functions of the device and not a set of direction for how to use the device. Students will need to identify the sensor(s) the device uses and the feedback that helps the device function properly.



Evaluation:

1. Students will select an example of an automated device and research how it works.
    a. Students will create a diagram of the device on poster board, tri-fold board, PowerPoint, or Microsoft Word. Students must label the parts of the device and include a caption explaining how the parts work together.
    b. Students will include required vocabulary in the presentation.
    c. Use any of the following resources:

       The New Way Things Work by David Macaulay

       The Way Things Work by David Macaulay and Neil Ardley

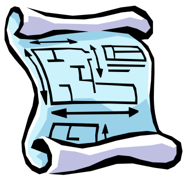
       The Way Things Work: The Complete Illustrated Guide to the Amazing World of Technology by Chris Oxlade

       How Stuff Works
       http://www.howstuffowrks.com

    d. Students will create a flow chart (algorithm) showing how the device works.
    e. Students will present their automated device to the class and demonstrate if possible.

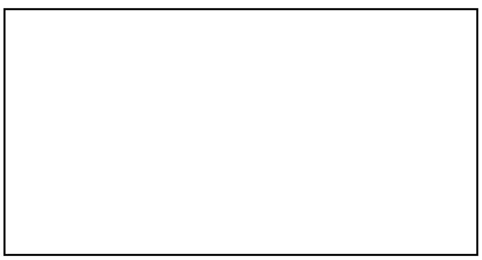
Extension:

- Make devices using electrical circuits. Create a flow chart showing how the device works. Identify the input and output.
- Show or read Dr. Seuss's The Lorax. Create a flowchart outlining the actions and decisions that were made leading to the destruction of the environment.
- Write an essay using any of the flow charts created.
- Create a flowchart showing the steps in a volcanic eruption, seed germination, life cycle, or formation of a tornado or hurricane.

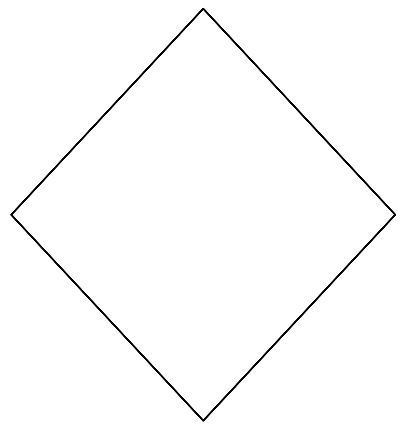


Flow Chart Templates

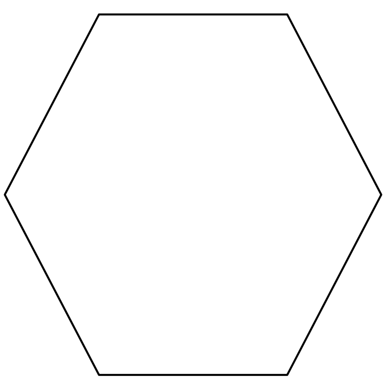
Cut out and trace the patterns on construction paper. Glue the symbols paper to create a flow chart



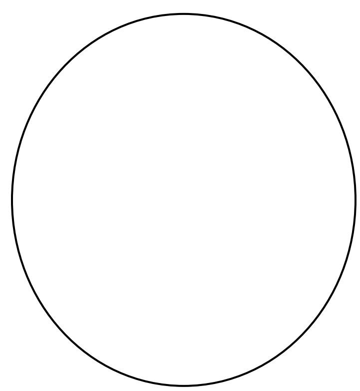
measurement



decision



action



stop, start, time delay

❖ Introduction to LEGO MINDSTORMS Hardware

Step Three: Directed Exploratory Lab: *Building with LEGOS*

1. Explain that students will be creating their own control systems using LEGO Mindstorms NXT building materials and software.

2. Explore the LEGO Mindstorms kit in groups. Look at each part and discuss possible functions of each part within the group. Identify sensors, input and output ports, motors, and explore how pieces fit together.

Step Four: Open ended Design Challenge: *Building a Can Push Vehicle*

1. Present the Design Challenge to students. Each group will construct a device that will travel the streets of your town looking for aluminum cans to recycle. The device should be capable of turning as needed to find and push the cans into the recycling center. A can measures approximately 2.5 inches in diameter.

2. The vehicle should be constructed using components from the LEGO Mindstorms/RoboLab kit. Each kit contains two light sensors, one touch sensor, two electric motors, and one lamp to use in the construction.

3. Students should complete the following steps prior to building.
   - Explore LEGO parts.
   - Develop a functional description of the vehicle which describes actions the vehicle must be capable of accomplishing during operation.
   - Generate several ideas, sketching them on paper to discuss with the group.
   - Construct the vehicle.
   - Test the model by pushing it over various terrains. Check for sturdiness.
   - Modify the model if needed based on initial testing.
   - Start thinking about what the program must include that will allow the vehicle to accomplish the task.

4. Students may select one of the construction models provided in the <u>DTEACh: Automation and Control Institute Binder</u>. Examples can be found in the section *titled Legos Laboratory – Longhorn Recycling Vehicle*.

Step Five: Project Reporting

1. Each group will share their final model. Students should discuss the following:
    a. The construction of the model.
    b. How they decided on the design they used.
    c. Challenges of construction and how they overcame those challenges.

2. Identify vocabulary used throughout the discussions such as sturdy, friction, gears, system, and more.
3. Students should discuss the modifications they made to their original design.

Engineering Journal
Building a Longhorn Recycling Vehicle

Sketch your ideas for constructing a Longhorn Recycling Vehicle that will be able to push a can into a 'recycling center.'

❖ Introduction to LEGO MINDSTORMS Software

Step Three: Directed Exploratory Lab: *Programming with NXT or RoboLab*

1. Step through basic programming skills using the directions from <u>DTEACh: Automation and Control Institute Binder.</u> Refer to the section titled *Automation and Control Laboratory: RoboLab Inroduction – Parts 1and 2 or MINDSTORMS NXT Introduction.*

2. Together, the class will write a simple program to download on the vehicle build earlier.

Step Four: Open ended Design Challenge: *Programming a Can Push Vehicle*

1. Review the Longhorn Recycling Vehicle Single Can Push Design Challenge. Students will program their vehicles to push a single empty can into the 'recycling center.' Refer to the specifications in the <u>DTEACh: Automation and Control Institute Binder.</u> The section is titled *LRV Single Can Pushing Flow Chart Laboratory.*
   - The can is approximately 12 inches in front and 10 inches to the left of the LRV. The LRV must drive up to the can by going straight 12 inches, turn left 90 degrees, go straight 10 inches, and then push the can forward 6 inches into the 'recycling center'.

2. Students will first create a flowchart of the program.

3. Once each group has discussed their program with the teacher, they may begin programming using RoboLab or MINDSTORMS NXT.

4. Students will download the RoboLab or NXT program into their vehicles to test.

5. Students must modify the program until their vehicle can accomplish the task. Assign a time constraint for students to meet.

Step Five: Project Reporting

1. Each group will demonstrate their vehicles on the recycling course. Students should also present and explain their programs.

2. Discuss the results of each vehicle and changes students would make to improve performance.

3. Student will evaluate their experience in their journals or using the *Longhorn Recycling Vehicle Challenge Journal* page. Students must answer questions such as:
   - Explain the results of the Design Challenge. Did your vehicle perform as you expected? Why or why not?
   - What would you do to improve the design of your vehicle? program?
   - What have you learned from this experience about working with NXT or Robolab, teamwork, and yourself?

Journal: Longhorn Recycling Vehicle Challenge

1. Explain the results of the Design Challenge. Did your vehicle perform as you expected? Why or why not?

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2. What would you do to improve the design of your vehicle? program?

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3. What have you learned from this experience about working with NXT or Robolab, teamwork, and yourself?

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❖ Next Steps in Building and Programming

Step Three: Directed Exploratory Lab: *Build and Program a Star Trek door*

1. As a class step through the MINDSTORMS NXT complete palette.

2. Together build and program a Star Trek door using directions from DTEACh: Automation and Control Institute Binder.

3. Students will test their doors and discuss modifications they could make to improve the performance or alter the resulting task.

Step Four: Open ended Design Challenge: *Three Mid-Level Design Challenges*

1. Students will work in groups to complete one of the following tasks. Build and program:
    - a better mousetrap - Design a device that will capture a mouse in a non-lethal and automatic manner. The mousetrap should be triggered automatically, holding the mouse until you desire to release it elsewhere.
    - an automatic putt returner - Help someone practice their put-put golf swing skills. The putting mechanism should receive a putted ball, indicating a proper stroke, and then return the ball to the user for another shot.
    - a mechanimal – Design and program a model of an animal that mimics its behavior or an adaptatation.

2. Students should complete the following steps prior to building.
    - Explore LEGO parts.
    - Develop a functional description of the device which describes actions it must be capable of accomplishing during operation.
    - Generate several ideas, sketching them on paper to discuss with the group.
    - Construct the device.
    - Test the sturdiness of the model.
    - Modify the model if needed based on initial testing.
    - Start thinking about what the program must include that will allow the device to accomplish the task.

3. Students should complete the following steps prior to programming.
    - Create a flowchart of the program.
    - Explain the program to the teacher
    - Begin programming using RoboLab or MINDSTORMS NXT.
    - Download the RoboLab or NXT program into devices and test.
    - Modify the program until the device can accomplish the task.

Step Five: Project Reporting

1. Each group will demonstrate their devices. Students should explain how they constructed their devices and explain their programs.

4. Discuss the results of each device and changes students would make to improve performance.

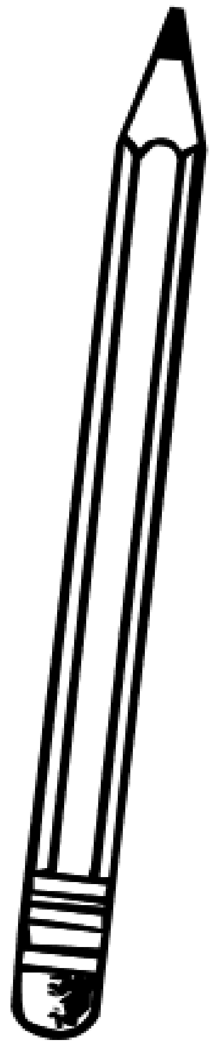
5. Student will evaluate their experience in their journals or using the *Design Challenge Journal* page. Students must answer questions such as:
   - Explain the results of the Design Challenge. Did your device perform as you expected? Why or why not?
   - What would you do to improve the design of your device? program?
   - What have you learned from this experience about working with NXT or Robolab, teamwork, and yourself?

Engineering Journal

Design Challenge: ______________________________

Sketch your ideas for constructing your device.

Journal: Design Challenge: ___________________



1. Explain the results of the Design Challenge. Did your device perform as you expected? Why or why not?

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2. What would you do to improve the design of your device? program?

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3. What have you learned from this experience about working with NXT or Robolab, teamwork, and yourself?

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❖ More Design Challenges

Step Four: Open ended Design Challenge: ***Three Mid-Level Design Challenges***

1. Students will work in groups to complete one of the following tasks. Build and program:
    - Amusement Park Ride
    - Lunch Box Alarm
    - Dr. DeSoto's Dentist Chair
    - Silent Alarm Clock
    - Storytelling with Mechanimals
    - Soccer Ball Return
    - Automatic Soccer Goalie
    - Batting Practice
    - Catapults
    - Fishing Machine
    - Airport Security Screener
    - Pinball Machine

2. Students should complete the following steps prior to building.
    - Explore LEGO parts.
    - Develop a functional description of the device which describes actions it must be capable of accomplishing during operation.
    - Generate several ideas, sketching them on paper to discuss with the group.
    - Construct the device.
    - Test the sturdiness of the model.
    - Modify the model if needed based on initial testing.
    - Start thinking about what the program must include that will allow the device to accomplish the task.

3. Students should complete the following steps prior to programming.
    - Create a flowchart of the program.
    - Explain the program to the teacher
    - Begin programming using RoboLab or MINDSTORMS NXT.
    - Download the RoboLab or NXT program into devices and test.
    - Modify the program until the device can accomplish the task.

Step Five: Project Reporting

1. Each group will demonstrate their devices. Students should explain how they constructed their devices and explain their programs.

2. Discuss the results of each device and changes students would make to improve performance.

3. Student will evaluate their experience in their journals or using the *Design Challenge Journal* page. Students must answer questions such as:
   - Explain the results of the Design Challenge. Did your device perform as you expected? Why or why not?
   - What would you do to improve the design of your device? program?
   - What have you learned from this experience about working with NXT or Robolab, teamwork, and yourself?

Evaluation:

1. Students will complete individual and group evaluation rubrics.

2. Students may also present their final products to students in other classes or as part of a school robotics fair.

Engineering Journal

Design Challenge: ______________________________

Sketch your ideas for constructing your device.

Journal: Design Challenge: ___________________

1. Explain the results of the Design Challenge. Did your device perform as you expected? Why or why not?

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2. What would you do to improve the design of your device? program?

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3. What have you learned from this experience about working with NXT or Robolab, teamwork, and yourself?

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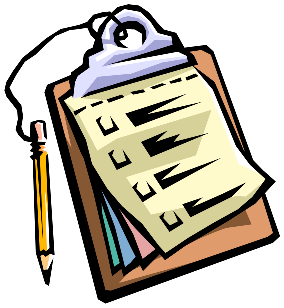
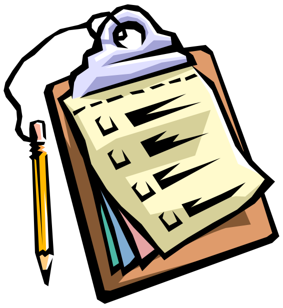


Design Challenge Evaluation

	Does not meet expectations 1	Meets few expectations 2	Meets most expectations 3	Meets all expectations 4
ROBOT				
The design is detailed and labeled with parts needed to build the robot.				
Students made necessary modifications to the original design to allow the robot to complete the task(s).				
The robot is sturdy and does not fall apart when handled or running.				
The robot meets all design criteria. The students followed directions and specifications.				
The robot is able to complete the task(s).				
MINDSTORMS PROGRAM				
Students wrote a MINDSTORMS program that works successfully with the robot.				
Students demonstrated understanding of MINDSTORMS icons, terminology, and programming concepts.				
STUDENT PERFORMANCE				
All students contributed to building and programming the robot.				
Students worked as a team to solve problems and complete the task.				
The students are able to explain the robot design and placement of parts.				
Students are able to explain how the ROBOLAB program works.				
Students are able to explain how they solved design and programming problems throughout the project.				
			Grade	



NAME ______________________

Design Challenge
Individual Evaluation

	YES	SOMEWHAT	NO
The student worked cooperatively with the group to plan and build the device.			
The student participated in each step of the process.			
The student considered other students' ideas.			
The student was able to explain the design, construction, and program			
The student used time wisely and stayed on task throughout the project.			
		GRADE	

Comments: ____

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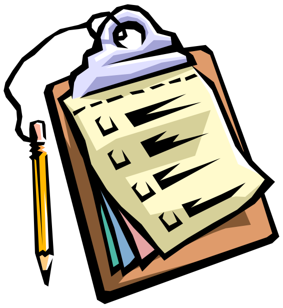

NAME ____________________

Design Challenge
Group Evaluation
(to be completed by group members)

	YES	SOMETIMES	NO
Our team worked cooperatively to plan and build the device. Everyone helped build and solve problems.			
Our device looked the way we wanted it to.			
Our device accomplished the task.			
The members of our team helped each other stay involved in the project.			
We listened to and used each other's ideas.			

Each member of the team contributed by: ____

____

____

We were an effective team because: ____

____

Our team needs to improve at: ____

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Our group earned a grade of: ___________________