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IEEE Lesson Plan:
Robot Basketball

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Lesson Focus
This lesson demonstrates the difference between precision and accuracy. Students design a device that can shoot a basketball free-throw shot accurately every time.

Lesson Synopsis
Students learn about accuracy and precision by working in teams to design and build a "robotic basketball player" for the World Robot Basketball League (RBL) that can accurately shoot a free-throw shot 3 times in a row.

Age Levels
10-18

Objectives
During this activity, students will:

- Explore precision and accuracy.
- Design & build a device that can throw a free-throw shot accurately.
- Implement the engineering design process to solve the design challenge.

Anticipated Learner Outcomes
As a result of this activity, students will have:

- Explored precision and accuracy.
- Designed & built a device that can throw a free-throw shot accurately.
- Implemented the engineering design process to solve the design challenge.

Lesson Activities
The teacher will lead a class discussion about basketball and the different kinds of shots basketball players perform. A student will demonstrate how they throw a free-throw shot in basketball. The teacher will introduce the design challenge and will discuss the difference between accuracy and precision. Each team will design & build a "robotic" basketball player that can shoot 3 free-throw shots successfully every time. During final testing and team share out, the class will keep track each team's percentage of accuracy and precision.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Worksheets (attached)
- Student Resource Sheets (attached)

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Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- Accuracy and Precision: (www.mathsisfun.com/accuracy-precision.html)
- Lever: (www.juniorengineering.usu.edu/workshops/machines/machines.php)
- TryEngineering (www.tryengineering.org)

Recommended Reading

- Robot (DK Eyewitness Books) (ISBN: 978-0756602543)
- Levers (Simple Machines) (ISBN: 978-1403485632)
- Real World Math: Basketball (9781602792456)

Optional Writing Activity

- Students could write short stories about their team's free-throw player and/or the World Robotic Basketball League (WRBL), personifying the "robot(s)."
- Students could create an ad that will promote the WRBL to draw more people to the games.
- Students could write an explanatory essay detailing the steps their robot takes to make an accurate free-throw shot.

For Teachers:
Teacher Resource

Lesson Goal
The goal of this lesson is for students to design & build a "robotic" basketball player that can shoot 3 free-throw shots successfully every time. During final testing and team share out, the class will keep track each team's percentage of accuracy and precision.

Lesson Objectives:
During this activity, students will:

- Explore precision and accuracy.
- Design & build a device that can throw a free-throw shot accurately.
- Implement the engineering design process to solve the design challenge.

Materials:
Put all of the materials for activity 2 & 3 onto a resource table

- Pieces of corrugated cardboard (different sizes cut of boxes)
- Card stock and/or file folders
- Cups and Plates (foam, plastic and paper all different sizes)
- Plastic spoons
- Rulers
- String
- Pipe cleaners
- Craft Sticks
- Straws
- Binder Clips (all sizes)
- Paper Clips (all sizes)
- Rubber Bands
- Craft Wire
- Skewers
- Clay
- Scissor
- Masking Tape
- Glue
- Paper and/or Construction paper
- Markers
- Ping Pong Balls (1 per team, the ones painted like a basketball are fun or use a sharpie to add the lines yourself)
- Waste Paper Basket
- Design Challenge Worksheet
- Optional: Basketball

For Teachers (continued):

- **Testing Zone Materials**

  Set up the Testing Zone with a "NET" - waste paper basket or a plastic cup (tape cup down) on a desk with a piece of masking tape on the floor 6 feet away (can make it longer or shorter depending on age of your students). Have the 3 testing ping-pong balls in a cup at the starting line. Another set up option is to tape the cup "net" up to the wall (about 2 feet from the top of the desk) and place a desk about 6 feet away.
  - Waste Paper Basket (younger students) OR Plastic Cups (Different sizes- the smaller the cup the more challenging)
  - Masking Tape (to mark where the ball lands)
  - Marker (to put Team # or name on the masking tape)
  - 3 Ping Pong Balls (the ones painted like a basketball are fun or use a marker to add the lines yourself)

- **Time Needed**
  - Three to four 45 minute sessions

- **Procedure**

INTRODUCION (1/2 hour)

1. Break students into teams of 3-4.
2. If you have a basketball, hold it up and ask…how many of you have every played basketball? What types of shots do players have to make? [The official types of shots involved in basketball are the mid-range shot, the layup, the three-pointer, the dunk, the alley-oop, the half-court shot, and the free-throw shot.]
3. Ask a student to demonstrate the free-throw shot by throwing a crumpled up paper into a wastepaper basket 6 feet away. Point out motion from the arm specifically from the elbow to the hands. Ask (or tell if they don't already know about simple machines): What simple machine does this part of the arm look like to you? *[A lever is a rigid bar that rotates around a fixed point called a fulcrum, which lifts or moves loads. In an arm, the elbow is the fulcrum and the forearm is the stiff bar.*

For Teachers (continued):

With a third-class lever, the effort force is applied between the fulcrum and the resistance force. Examples of third-class levers include tweezers, ice tongs, baseball bats, and hockey sticks. In a third-class lever the effort and resistance both move in the same direction. Third-class levers always decrease the output force, but gain in terms of the distance and speed with which the resistance moves.] Above lever content and images source:(www.juniorengineering.usu.edu/workshops/machines/machines.php)

4. Finish discussing the design challenge criteria and constraints.
5. Make special note of how students' "robots" must be ACCURATE (successful in getting their "basketball" into the "net" 3 times in a row. Their robot must be 100% accurate. See Teacher Resource for information the difference between accuracy and precision. Have two students demonstrate - one will shoot the free-throw shot 3 times and the other will mark where the paper lands with masking tape. Calculate the student's precision and percentage of accuracy.
6. Give students an hour to design, build, test and redesign their robot. Students can either test at their own station where they set up a mock testing zone of their own or they can use the class "testing zone."
7. Each team will share the answers to their reflection questions and then demonstrate their "robot" basketball player.
8. One person in the class needs to be assigned the ball maker and will use the masking tape (with the team number or name) to mark where their balls land if they don't get into the "net."
9. The teacher or another student can keep a chart on the board with the Teams and their accuracy and precision scores.

	Accuracy (x/3*100) 33%, 67%, 100%	Precision (Yes, No, Somewhat) Note: have teams draw a sketch
Team 1		
Team 2		
Team 3		
Team 4		
Team 5		

NOTE: If students are having a hard time getting started with their design, you might want to lead them to a catapult type design. Students may be tempted to try to slingshot the balls, but that design will not be effective, as the design requires an arc motion for the ball.

Student/Resource:
Accuracy and Precision

- Accuracy is how close a measured value is to the **actual (true) value**.
- Precision is how close the measured values are **to each other**.

Examples of Precision and Accuracy:

Low Accuracy
Low Precision

High Accuracy
High Precision

So, if you are playing soccer and you always hit the left goal post instead of scoring, then you are **not** accurate, but you **are** precise!

SOURCE: (www.mathsisfun.com/accuracy-precision.html)

Student Worksheet: Design Challenge

◆ **Scenario**

The World Robotic Basketball League's top ranked team, the BOTS are looking for the best free-throw player they can find. Tryouts are today!

◆ **Design Challenge**

Design and build a "robot" basketball player that can shoot three free-throw shots accurately each time. The player that is the most accurate will get the job!

◆ **Criteria**

- Net must be 2 feet above the floor (or desk) and 6 feet from the "robot."

◆ **Constraints**

- Use only the materials provided.
- Only get 3 free-throw shots for the tryout.

◆ **Planning Stage**

Meet as a team and discuss the problem you need to solve. Then develop and agree on a design for your robot. You'll need to determine what materials you want to use.

Draw your design in the box below, and be sure to indicate the description and number of parts you plan to use.

Team members:____

Team Name: ____

Brainstorm designs for your Robot Basketball Player:

Student Worksheet:
Design Challenge

Choose your best design and sketch it here:

◆ **Construction Phase**

Build your robot. During construction you may decide you need additional materials or that your design needs to change. This is ok – just make a new sketch and revise your materials list.

◆ **Testing Phase**

Each team will test their robot. If your design was unsuccessful, redesign and test again. Be sure to watch the tests of the other teams and observe how their different designs worked.

Sketch your Final Design

Student Worksheet: Design Challenge

◆ Evaluation Phase
Evaluate your teams' results, complete the evaluation worksheet, and present your findings to the class.

Use this worksheet to evaluate your team's results in the Robot Basketball Lesson:

1. What went well?

2. What didn't go well?

3. Where there any trades-offs (an exchange that occurs as a compromise or concession) you had to make with your design? If so, explain:

4. What is your favorite element of your "Robot"?

Student Worksheet (continued): Design Challenge

5. If you had time to redesign again, what changes would you make?

Accuracy: _______________ %

Precision: __________________

For Teachers:
Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:
- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆**National Science Education Standards Grades 5-8 (ages 10 - 14)**

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of
- ✦ Motions and forces
- ✦ Transfer of energy

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop
- ✦ Abilities of technological design
- ✦ Understandings about science and technology

◆**National Science Education Standards Grades 9-12 (ages 14-18)**

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of
- ✦ Motions and forces
- ✦ Interactions of energy and matter

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop
- ✦ Abilities of technological design
- ✦ Understandings about science and technology

◆**Next Generation Science Standards – Grades 3-5 (Ages 8-11)**

Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:
- ✦ 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

Energy

Students who demonstrate understanding can:
- ✦ 4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.

For Teachers:
Alignment to Curriculum Frameworks

◆**Next Generation Science Standards Grades 3-5 (Ages 8-11)**

Engineering Design

Students who demonstrate understanding can:

- 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

◆**Next Generation Science Standards Grades 6-8 (Ages 11-14)**

Motion and Stability: Forces and Interactions

- MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Engineering Design

Students who demonstrate understanding can:

- MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

◆**Principles and Standards for School Mathematics (ages 11 - 14)**

Measurement Standard

-Apply appropriate techniques, tools, and formulas to determine measurements.

- use common benchmarks to select appropriate methods for estimating measurements

◆**Principles and Standards for School Mathematics (ages 14 - 18)**

Measurement Standard

- Apply appropriate techniques, tools, and formulas to determine measurements.

- analyze precision, accuracy, and approximate error in measurement situations.

For Teachers:
Alignment to Curriculum Frameworks

◆ **Common Core State Standards for School Mathematics Grades 2-8 (ages 7-14)**

Measurement and data

- Measure and estimate lengths in standard units.
  - CCSS.Math.Content.2.MD.A.1 Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.
- Represent and interpret data.
  - CCSS.Math.Content.2.MD.A.3 Estimate lengths using units of inches, feet, centimeters, and meters.

Ratios & Proportional Relationships

- Understand ratio concepts and use ratio reasoning to solve problems.
  - CCSS.Math.Content.6.RP.A.3c Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.

◆ **Standards for Technological Literacy - All Ages**

Design

- Standard 10: Students will develop an understanding of the role of
- troubleshooting, research and development, invention and innovation, and experimentation in problem solving.