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| **TEAM Lesson Plan Template** |
| Teacher: Dr. Jeremy Entner |
| Subject/Grade: Probability and Statistics / 8th Grade / High School |
| Lesson Title: Bouncy Balls |
| **STANDARDS** | **Identify what you intend to teach.** State, Common Core, ACT College Readiness Standards and/or State Competencies; Enduring Understandings and Essential Questions. |
| **SMP 4.** Model with mathematics.**SMP 5**. Use appropriate tools strategically. **8.SP.A.2** Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line and informally assess the model fit by judging the closeness of the data points to the line.**8.SP.A.3** Use the equation of a linear model to solve problems in the context of bivariate measurement data, interpreting the slope and intercept. For example, in a linear model for a biology experiment, interpret a slope of 1.5 m/hr as meaning that an additional hour of sunlight each day is associated with an additional 1.5 cm in mature plant height.**B.S.ID.B.3** Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.**a**. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.**S.ID.B.12** For bivariate measurement data, be able to display a scatterplot and describe its shape; use technological tools to determine regression equations and correlation coefficients. |
| **OBJECTIVE(s)/Sub-Objectives** | **Connect prior learning to new learning.** Clear, Specific, Observable, Demanding, High Quality, Measurable, Aligned to Standard(s), and Integrated with other subjects, build on prior student knowledgeStudent-Friendly (I Can Statement) |
| I can find a linear equation to describe the number, *b*, of times that I can bounce a ball in *t* seconds.  |
| **MATERIALS AND RESOURCES**  | **Content-related:** Clearly supports lesson objective(s); rigorous & relevant; Incorporates multimedia & resources beyond the textbook.  |
| **Activities & Materials** Stopwatch (or any clock showing seconds <https://www.timeanddate.com/stopwatch> ), projector or whiteboard/marker, graphing calculator or computer with graphing capability. For each pair of students: Bouncy Ball, Recording Sheet, Graph paper, pencil, ruler, hard flat level surface such as a floor or table top, calculator **What if the technology is not working?** This activity works for the 8th grade standard without technology beyond the second hand on a clock. The informal fit can be done by hand with a ruler and pencil on graph paper. For the high school standards, a calculator really is helpful.**Routine for distributing materials.** After placing students in pairs, pass out graph paper to recorders and pass around a bucket of bouncy balls.  |
| **ACCOMMODATIONS/ADAPTATIONS** | **Learning styles and interests.** Anticipate learning difficulties, regularly incorporate student interests & cultural heritage; differentiate instructional methods. |
| **Modifications/Plans for Diverse Learners** **Differentiation****----- Content** Data interpretation can be informal or formal. “This data is more spread out” vs. “The standard deviation is 2.345, which is greater than the other standard deviation of 2.043.” **----- Process** The point of this activity can be achieved with any activity that is easily and quickly repeated and whose outcome is quickly determined. For example, roll a die and ask how many times 1 appears in a certain period of time. **-----Product** Most students will prepare a histogram by hand. Some may use technology to prepare the histogram.**Accommodations****\_x\_\_ Extended Time** Students may need extra time to interpret their data, but everyone who bounces a ball should stick to the time limits.**\_x\_\_ Peer Tutoring** Students working in pairs will help each other**.** **\_x\_\_ Modified Assignments** See “process” above. Students who have difficulty bouncing a ball may record data instead, or they may conduct an alternative activity such as rolling a die. **\_\_\_ Other** **Early Finishers:** |

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| **MOTIVATING STUDENTS/ANTICIPATORY SET** | **“Hook”: Engage students’ attention and focus on learning.** Personally meaningful and relevant. |
| Demonstrate bouncing a ball and counting the bounces. Point out that the class is going to see who can bounce the ball the fastest. Fast is good, but control is necessary. If the ball bounces away, time does not stop. The bouncer must keep the count, retrieve the ball, and continue bouncing and counting until time is up. Mention that there is a prize for the team with the largest number of bounces and for the team with the largest average number of bounces.  |
| **INSTRUCTIONAL PROCEDURES** | **Step-by-Step Procedures-Lesson Sequence: Basic to Complex.** Lesson includes visuals, modeling, logical sequencing and segmenting (beginning, middle, ending); essential information; concise communication; grouping strategies; differentiated instructional strategies to provide intervention & extension; seamless routines; varied instructional strategies; key concepts & ideas highlighted regularly. |
| ***Introductio*n**We have looked at data sets and talked about measures of the center and measures of variability. Today we are going to collect some data. We will discuss the centers of our data sets, and we will also try to find an equation that matches the data. **Motivating Students** \_x\_ Game \_x\_ Small Rewards **Presenting Instructional Content** \_x\_ Hands-On \_x\_ Game \_x\_ Modeling***Instructional strategies:*****Modeling and Guided Practice** **Activity 1**Designate a student as the class timekeeper. Ensure that the timekeeper has and can operate a stopwatch. Group the remaining students into pairs (Or triples. If using triples, one student is the retriever – if the ball bounces away the retriever goes to get it)**.** Within each pair, one student becomes the bouncer and the other becomes the recorder. Pass a bucket of balls around the class and have each bouncer take one. Pass out copies of the Bouncy Ball Recording Worksheet and a piece of graph paper. Have bouncers move, if necessary, so that they have a flat, level surface on which to bounce the ball. Have the bouncers take a few practice bounces to get a feel for the ball. The Timekeeper should get everyone’s attention and announce, “We will bounce for 10 seconds.” “Ready, Go” wait ten seconds “Stop.” Bouncers tell recorders their number of bounces. Recorders record the number on the worksheet in the “# of Bounces” blank for Trail #1. If students are using calculators, the recorder should also enter this number in a statistical list at this point. The Timekeeper gets everyone’s attention again, says “10 seconds. Ready, Go.” wait ten seconds “Stop.” Continue this process for thirty trials. After the thirty trials, the timekeeper should join one of the pairs of students. If using calculators, students may compute 1 Variable Statistics at this point. Have students make a histogram on their graph paper using the numbers from their worksheet. Prompt them with these questions: 1. What is the smallest number of bounces that you got? (Get this number from each group, and determine the smallest in the whole class)
2. What is the largest number of bounces that you got? (Get this number from each group, and determine the smallest in the whole class)
3. How many bins should we use for the histograms?
4. If we want to compare results from group to group, should everyone use the same number of bins or a different number of bins? (*everyone should use the same bins; reach group consensus on what these should be).*
5. Now that we have our histograms, look compare yours to the ones produced by the other groups. Do the histograms look roughly the same, or wildly different?
6. What your average number of bounces? (Get this number from each group, and compare across the class)
7. Are our averages roughly the same?
8. Were we all bouncing the ball the same way? Were our bounces about the same height? How do our answers to this question relate to the question about the averages?
9. What is the spread/standard deviation for your data set? (Get this number from each group, and compare across the class)
10. Are our spreads/standard deviations roughly the same?

 **Activity 2**Designate a student as the class timekeeper. Ensure that the timekeeper has and can operate a stopwatch. Designate a student as the class recorder. Ensure that the recorder can construct a six histograms visible to the whole class either on a whiteboard or using a computer/projector. Group the remaining students into pairs (Or triples. If using triples, one student is the retriever – if the ball bounces away the retriever goes to get it)**.** Within each pair, one student becomes the bouncer and the other becomes the recorder. Ensure that bouncers have a bouncy ball and that recorders have the Bouncy Ball Recording Worksheet. Demonstrate how to bounce the ball, emphasizing a consistent height for each bounce. Choose a height that is comfortable for most of the class, but everyone should attempt to bounce the ball the same way. The Timekeeper should get everyone’s attention and announce, “We will bounce for 10 seconds.” “Ready, Go” wait ten seconds “Stop.” Bouncers tell recorders their number of bounces. Recorders record the number on the worksheet in the “# of Bounces” blank for 10 seconds. Each recorder will give the number of bounces to the class recorder. The class recorder will create a histogram using each of the numbers. Label the histogram “10 seconds”What is the mean for the data set? What is the standard deviation? The class recorder should write these numbers beneath or beside the histogram. After answering these questions for the 10-second data set, the Timekeeper should get everyone’s attention and announce, “We will bounce for 20 seconds.” “Ready, Go” wait twenty seconds “Stop.” Bouncers tell recorders their number of bounces. Recorders record the number on the worksheet in the “# of Bounces” blank for 20 seconds. Each recorder will give the number of bounces to the class recorder. The class recorder will create a histogram using each of the numbers. Label the histogram “20 seconds.” What is the mean for the data set? What is the standard deviation? The class recorder should write these numbers beneath or beside the 20 second histogram. After answering these questions for the 20-second data set, repeat the process for 30 seconds, then 40 seconds, then 50 seconds, and finally 60 seconds. Discuss the histograms. * Do the histograms share any similarities?
* How are the bins made? Should they be the same or different?
* If the numbers change a lot, would it be good to use the same size bins, but locate them differently?
* Does the standard deviation stay roughly the same or does it change? If it changes, how does it change?
* Are the means changing? If so, is there any type of pattern to their change?

Now make a scatterplot of the data from the histograms. The format should be something like this, with the number of bounces for each group for each of the times. (To reduce the amount of data entry, you could decide to plot just the mean for each time, giving just 6 data points).  Discuss the scatterplot. Use equity cards to get answers from multiple students. * Is there any trend that is visible from the picture?
* Does it look like a line, a curve?
* Can you draw this line or curve by hand? After drawing it, can you find a formula for the line/curve?
* Can you draw this line or curve using regression on a calculator / computer? If so, you should also get the equation.
* Using the equation you produced by hand or with regression, find the value of the function at 10/20/30/40/50/60 seconds. How do these values compare to the sample means of each histogram?
* Can we plot the means from the histograms on this scatterplot?
* How many times do you think a randomly selected student could bounce the ball in 35 seconds? 45 seconds? Does this guess represent an average or an actual number of times bouncing? Do you think that this number would actually be correct? Is there a better guess you can make? ( *The goal is to get students to provide an interval answer “Between \_\_\_ and \_\_\_ many times.”* )
* What would you guess for 200 seconds? Do you believe this guess? Would the function still apply? Would a person get tired and speed up or slow down their bounces?

Get one of the bouncers to volunteer. Have this volunteer leave the room for a minute. Ask the class to estimate the number of bounces for \_\_\_ seconds (a number of seconds not already computed). Hide the estimate. Have the volunteer return and bounce for that many seconds. Reveal the guess. Discuss the result. * Were we right? Were we wrong?
* If we were wrong, did we do anything wrong?
* Can you draw this line or curve by hand? After drawing it, can you find a formula for the line/curve?
* Can you draw this line or curve using regression on a calculator / computer? If so, you should also get the equation.

**Dr. Entner’s comments:** If a ball runs loose, you count that. It will decrease someone’s total, but who cares… Outliers…… Should we include it in with the rest? Yes, No, depends on what happened. A minor bauble, keep it, the ball running out of the room, throw that data out. Does it have a wild effect on our means or standard deviations? Compute with or without. **Check for Understanding (CFU) –** ***What am I doing for students that progress at different rates?*** ***What do I do if they get it?*** ***What do I do if they don’t get it?***  |
| **QUESTIONING/THINKING/PROBLEM SOLVING (embedded throughout)** | **Balanced mix of question types.** Utilizes Blooms Taxonomy/Webb’s Depth of Knowledge; high frequency; purposeful & coherent; require active responses; balance based on volunteers/non-volunteers, ability, & gender; lead to further inquiry & self-directed learning.  **Implement four types of thinking (Analytical, Practical, Creative, & Research-based) & Teach/Reinforce problem-solving types**. Provide opportunities for students to generate ideas & alternatives; analyze, evaluate & explain information from multiple perspectives& viewpoints. |
| **Questioning** **Knowledge:**What is the smallest number of bounces that you got? What is the largest number of bounces that you got? **Comprehension:** What is the average number of bounces in your group? What your average number of bounces? (Get this number from each group, and compare across the class)What is the spread/standard deviation for your data set? **Application:**If we want to compare results from group to group, should everyone use the same number of bins or a different number of bins? Now that we have our histograms, look compare yours to the ones produced by the other groups. Do the histograms look roughly the same, or wildly different? Are our averages roughly the same?Are our spreads/standard deviations roughly the same? **Analysis:** How many bins should we use for the histograms? Were we all bouncing the ball the same way? Were our bounces about the same height? How do our answers to this question relate to the question about the averages? **Synthesis:****Evaluation:** **Thinking**  \_x\_ **Practical** –Students are learning how to apply observations of a sample to make predictions about future outcomes. \_x\_ **Creative**– Students make predictions about what would happen when bouncing for an amount of time much larger than the times in the experiment. Students also have to decide on how many bins to use for their histograms. \_x\_ **Analytical** – Students formally or informally fit a function to the observed data.  \_x\_ **Research-based** – Students conduct an experiment, create a mathematical model, and answer several “what if” questions about expectations for values outside the observed data set. **\*What am I going to do to give Ss opportunity to?** **1. Generate variety of ideas:** **2. Analyze problems from multiple viewpoints:** **Problem Solving** **\_\_x\_ Categorization** Students categorize histograms based on means and standard deviations**.** **\_\_x\_ Drawing conclusions/Justifying Solutions** Students have to explain why their estimate for the number of bounces for the student who left the room are or are not correct. **\_x\_\_ Predicting** Outcomes Students predict outcomes for future events**\_\_x\_ Observing and Experimenting** |
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| **GROUPING** | **Maximize student understanding & learning** Varied group composition (race, gender, ability, & age); clearly understood roles, responsibilities & group work expectations; accountability for group & individual work; student opportunities for goal setting, reflection & evaluation of learning. |
| * Designate one student as the timekeeper. Other students work in pairs (with possibly one group of three).
* There is one timekeeper for the whole class. In each pair of students, one is the bouncer. The other is the recorder. For Activity 2, also designate a class recorder.
* Students will receive verbal instructions for their roles.
* Groups will complete a Bouncy Ball Recording Worksheet.
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| **ASSESSMENT** | **Formative and/or summative assessment.** A variety of assessments, including rubrics, measure achievement of objectives and informs instruction.  |
| ***Assessments: aligned with state stds; measurement criteria; measure student performance in more than 2 ways (project, experiment, presentation, essay, short answer, multiple choice test) (NOTE: Clearly identify where you will use each of these in your lesson; do not just check the box!)*****\_\_\_ ThinkLink Probe \_\_\_ Study Island \_\_\_ Teacher Made Test \_\_\_ Unit/Chapter Test \_\_\_ Project \_\_\_ Quiz** **\_\_\_ Group Assignment \_\_\_ Study Guide \_\_\_ Oral Presentation \_\_\_ Graphic Organizer \_\_\_ Exit Ticket** **\_\_\_ Journal \_\_\_ Questions/Answers** **\_\_\_Teacher Observation *(thumbs up/thumbs down, etc.)*\_\_\_ Solution to Real World Problem** **\_\_\_ Other \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**  *\****Students should achieve \_\_\_\_\_% mastery of this objective: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** |
| **CLOSURE** | **Reflection/Wrap Up.** Summarizing, reminding, reflecting, restarting, connecting. |
| ***During the conclusion part of creating an effective lesson plan teachers must sum up the ideas learned from the lesson. A teacher should also relate this information to future and past coursework to provide students with a broad understanding of the ideas learned. It is important to allow students enough time to ask questions, assert assumptions, and summarize the lesson during this part of the lesson plan.**** ***Review/Summary:*** We have seen that there is some variation in what happens when we conduct an experiment. We used histograms and a scatterplot to visually interpret data from an experiment. We found a mathematical model (formula) to represent what happened in our experiment. We used the model to make predictions about what would happen in future experiments. Our model does not predict exactly what will happen, but gives an approximation that allows us to expect that the actual outcome will lie within a predictable range of values.

**Recognize the team which had the greatest number of bounces in Activity 1. Recognize the team with the highest average number of bounces from Activity 1.** * ***Preview for next lesson: link what they did to day with where they are going next.***
* ***Upcoming assignments: remind them of any upcoming assignments.***

Turn to your partner and describe one thing that you learned today. **Follow-up Activities/Extension *These may be designed to create a longer or more intense lesson. For example, if the class is able to cover the material in a lesson much faster than expected, extensions may prove helpful. Extensions may also be useful in various parts of a lesson where the teacher (and class) decides they should spend more time on a skill or topic.******Reflection: You must reflect on every lesson you teach.*** |

**NOTES:**

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**Bouncy Ball Recording Worksheet**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Work with a partner. One person bounces the ball and counts (out loud, but quietly). The other person records the number of bounces.

Bounces in 10 seconds

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| **Trial #** | **# of Bounces** |  | **Trial #** | **# of Bounces** |  | **Trial #** | **# of Bounces** |
| **1** |  |  | **11** |  |  | **21** |  |
| **2** |  |  | **12** |  |  | **22** |  |
| **3** |  |  | **13** |  |  | **23** |  |
| **4** |  |  | **14** |  |  | **24** |  |
| **5** |  |  | **15** |  |  | **25** |  |
| **6** |  |  | **16** |  |  | **26** |  |
| **7** |  |  | **17** |  |  | **27** |  |
| **8** |  |  | **18** |  |  | **28** |  |
| **9** |  |  | **19** |  |  | **29** |  |
| **10** |  |  | **20** |  |  | **30** |  |

Bounces in 10/20/30/40/50/60 seconds

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| --- | --- |
| **# Seconds** | **# of Bounces** |
| **10** |  |
| **20** |  |
| **30** |  |
| **40** |  |
| **50** |  |
| **60** |  |