Lesson Title	Slacker Procedures & Systematic Variance with StringRacer®
Length of Lesson	1 Day
Created By	William Funderburk
Subject	Physics
Grade Level	7-12 (Physics)
State Standards	Physics: 1a, g;
DOK Level	DOK 4
DOK Application	Design, Apply Concepts, Analyze
National Standards	9 – 12: B (physical); E (technology)
Graduate Research Element	Statistical treatment of data

Student Learning Goal: This lesson is designed to provide a DOK 4 level of understanding for Mississippi State Science Standards Physics: 1a, g.

Physics: 1. Apply inquiry-based and problem-solving processes and skills to scientific investigations: (a) Use current technologies such as CD-ROM, DVD, Internet, and on-line data search to explore current research related to a specific topic; (g) Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.)

National Science Education Standards of Content 9 – 12
A (Inquiry): identify questions and concepts that guide scientific investigations.

E: (Science and Technology): abilities of technological design; understanding about science and technology

Materials Needed (supplies, hand-outs, resources): StringRacer®, Microsoft Excel

Lesson Performance Task/Assessment: Variance and error make their way into datasets thru three main causes: 1. Random sampling error, 2. Systematic variance due to improper procedures, and 3. Sampling bias in the collection of data. Using StringRacer®, student teams will learn to design a proper experiment employing replication and randomization and review of procedures. Student teams also compare results to datasets where improper procedures and identifying sources of systematic bias and variance in the collection of data.

Lesson Relevance to Performance Task and Students:
These lessons and performance tasks will increase students' interest in the subject through the use of technology resources (programming language, PowerPoint, internet) to generate a data set.

Anticipatory Set/Capture Interest:
Have two StringRacer® set- ups ready to go when the students arrive. Give a demonstration of the motion of the string racer down the string for students to view, measuring both distance of travel and time of travel.

Guided Practice:
Separate the students into an even number of teams. If you have two teams, one team will perform the "well-planned" experiment and the other team will perform the "poorly-planned" slacker experiment.

Discuss and brainstorm with all the students the kinds of errors that can occur when acquiring a data set for the string racer's time for travel for multiple distances. With leading questions, let the students "tease-out" all the issues.

Examples of topics that should come up are replication of trials, consistency of the string, minimizing string bounce, consistency of measurement of distance and time, measuring instruments and significant figures.

One team will perform the well-planned experiment and the other team will perform the same experiment with all procedures compromised. Examples of compromised procedures are multiple timers in place of repeated trials, changing out personnel during data acquisition, etc.

Independent Practice:

Student teams will use Microsoft Excel to graph their data sets of distance vs. time and perform a 2^{nd} order quadratic regression using the Excel Regression functions

Remediation and/or Enrichment: individual IEP; partner help throughout lesson; shorten parts of assignment; focus upon smaller elements of the process

Enrichment/Extension:
Let the students generate a PowerPoint presentation to teach an audience of students how to properly design an experiment using replication and review of procedures. Set up a seminar which includes students from other science classrooms as an audience for the student team design presentations.

Check(s) for Understanding:
Have the students verbalize out loud to each other the difference between 1. Random sampling error in the "well planned" data set and, 2. Systematic variance due to improper procedures in the "slacker" data set. Understanding this difference is of course the whole point of the exercise.

Closure:
Project all student graphs in front of the class to demonstrate the trends in their data. Class discussion should follow concerning the "problematic" data set. Have the students thru student discussion generate a list on the board of systematic errors of procedure which likely resulted in systematic variance in the "problematic" data sets.

Possible Alternate Subject Integrations:
*Math – can graph data sets using Microsoft Excel and superimpose a quadratic trend upon the data
*Language Arts – can use PowerPoint to deliver a public presentation of the design of experiment