Activity: Assessing the Power of Exercises with Sensors

Contributed by: Kansas State University, Computing and Information Systems Department, National Science Foundation GK12 INSIGHT Program

Prepared for http://www.teachengineering.org/

***Subject Area(s)**

Life Science
Biology
Science and Technology
Computer Science

***Associated Unit**

Enhancing Health - Sensors in Wellness, Health, and Medicine

***Associated Lessons**

- Sensors in Health, Wellness, and Medicine
- Advanced gaming interface devices in wellness and rehabilitation

***Associated Activities**

- Using Sensors in Wellness Day

***Grade:** 6 (5-7)

Time Required

45 minutes

Group Size

5 groups @ ~3-5 per group

Cost Per Group

1-5 Garmin Forerunner 305 heart rate sensor & logging devices @ ~$200
Total: about $200 - $1000

***Summary**

This exercise activity focuses on using sensors to determine the most "powerful" exercises in terms of which one have the biggest impact on heart rates. Students start with observing

and practicing a variety of exercises and then formulate a hypothesis that predicts which exercise will have the greatest impact on heart rate. Next, students work together to identify the independent variable, dependent variable and constant variables for the inquiry. Students conduct the experiment in teams and use heart rate monitors to measure their heart rate during each exercise. Students record data and analyze the graphs to generate results. They form and write up their conclusion in which they interpret whether their hypothesis was supported by the results. In addition, students create a health-related class survey and gather results. Afterwards, they graph the data in order to qualitatively assess the measure of variability. Then they calculate the mean to evaluate the measure of center for the answers to each question.

*Engineering Connection

Engineers design technologies that are being used to consistently and reliably monitor a wide range of body conditions, from blood glucose concentrations, to internal temperatures, to heart rates. By enabling near real-time feedback, engineers enable teams of athletes and trainers, patients and medical advisors, and other teams to assess the impacts of various actions and determine the best approaches for training and treatments.

*Engineering Category

1. Relating science and/or math concept(s) to engineering

***Keywords:** medicine, sensors, biomedical, heart rate sensors, health, wellness, treatment, monitoring, exercise, rehabilitation.

*Educational Standards

Shawnee School District Grade 6 (2010) from Kansas Science Standards -

- Objective 4006.01 - Identify a problem statement that can be answered through science investigation.
- Objective 4006.02 - Design and conduct investigations safely using appropriate tools, mathematics, technology, and techniques to gather, analyze and interpret data.
- Objective 4006.03 - Identify relationships between evidence and logical conclusions.
- Objective 4006.59 - Demonstrate comprehensive exercises which will promote health and well-being.

Pre-Requisite Knowledge

- Basic understanding of data sets and the scientific method.

*Learning Objectives

After this activity, students should be able to:

- Identify a problem statement that can be answered through science investigation.
- Design and conduct investigations safely using appropriate tools, mathematics, technology, and techniques to gather, analyze and interpret data.
- Identify relationships between evidence and logical conclusions.
- Demonstrate comprehensive exercises which will promote health and well-being.
- Graph and analyze data.

*Materials List

Each group needs:

- Garmin Forerunner 350 GPS and data logger with heart rate sensor.
- Exercise volunteer.
- Pencil and paper for recording hypothesis and data.
- A computer to view their heart rate data.
- A computer with a spreadsheet and graphing program to evaluate survey results.

Whole class needs:

- A computer to retrieve data from devices running the software for the data loggers.
- A program that allows screen captures.
- A USB drive or other way to transfer information to each group computer.
- A recharging center for the data logging devices.
- Access to water to wet the devices.
- A private place to put on the monitors.
- Space to exercise.
- Access to Youtube or a downloaded version of the videos (optional).

*Introduction / Motivation

This activity provides the students an opportunity to use sensors in a scientific experiment.

Vocabulary / Definitions

Word	Definition
Heart rate	A measure of how hard a human (or animal) is working, measure in beats per minute
GPS	Global Positioning System - used by the exercise devices to track location during runs.

*Procedure

Background

- Purchase Garmin Forerunner 305 GPS enabled trainer watches with heart rate sensors (or compatible model).
- Install Personal Trainer software.
- Charge each data logger watch for three hours or until display indicates charging is complete.

Before the Activity

- Plan classroom arrangement and spacing needed for exercises.
- Label each watch and associated sensor by group number.
- Add each watch:.

        - Push and hold the on button to turn watch on.
        - Put watch in cradle add attach USB cable to computer to connect.
        - Click the Windows start menu, select All Programs / Garmin / Training Center.
        - From the menu select "User" / "Add new device". The watch must be on, in the cradle, and connect to the computer for the software to find it.
        - The default user is fine. Type in a nickname like "Garmin01".
        - You can now remove the watch from the cradle.
    - Perform initial pairing:
        - Turn off all other devices when pairing a watch and heart rate sensor to avoid conflicts.
        - Make sure other heart rate sensors are more than 3 meters away when pairing.
        - Put on the associated sensor, moistening the back slightly and wearing it snugly on the chest. (See directions.)
        - Press "mode" button on the watch to get to menu.
        - Select Settings / General / Accessories / Heart Rate Monitor (press up, down, enter ("ok"), and mode ("back") buttons as needed).
        - Make sure "yes" is selected (if not, use the up/down/enter keys to set it), then highlight "Restart Scan" and hit enter.
        - It will return you to the previous menu and the the heart icon in the lower right should stop flashing and stay a constant heart.
        - If the heart is still not constant, add some water or a bit of aloe vera gel to the hard back of the heart monitor and try again.
    - Set the watch to record every second.
        - If necessary, press mode button to get back to the menu.
        - Select Settings / General / Data Recording. Press Enter to get the two-item drop down menu which may say "Smart Recording" (which is the default and should be used during training).
        - Press up to select "Every Second" and hit enter. Use "mode" button to back up to the main menu or simply press and hold the on button to turn off the device.

With the Students

- **Engage** (5 minutes) - Our focus today is on sensors and information technology in health and medicine. Think about your experiences. What kinds of sensors do we use to determine our level of health? [temperatures, scales, visual checks to see how pupils contract in response to light,

stethoscopes to hear heart rates, blood pressure monitors]

- Sensors are everywhere in health and medicine from "smart" hospital rooms that help monitor your health, to "smart" shoes that detect when someone falls, to "smart" pills that we swallow, and cancer-killing nanoparticles we inject (which are really tiny machines, but all that smart-there's no place to put the intelligence at that size).
- Many people don't have to take medicine, but for some people, it's live saving to take their medicine on a very regular basis. Why is that? [the relative amount of the medicine in our blood - it's concentration - typically goes up after ingestion, and then down illustrate curve] If it gets too low - its not good. What if we could track our levels continuously - in real time - to notice when that happened? What if we made it smart so it could remind us before the level got too low? How might it do that? [beep? phone cal?]
- Video. Let's take a look at a one minute video of how one company is solving this (show short video of a smart pill that is swallowed and sends you a text message if you forget to take your medicine.)
- The version with the good graphics is only in Chinese, but it has subtitles, it's only a minute, and the visuals are definitely worth it. We just turned down the sound and provided comments as it ran.
- Afterwards: What did you learn? Kids may note that the pills aren't permanent. But neither are most of the other pills and vitamins we take. :)

- **Explore** (5-10 minutes) - Hands on. Students will explore the problem, “Which type of exercise will raise my heart rate the most?”
- They will start with observing and practicing the following exercises: 1) jumping jacks, 2) squats, 3) jump rope, 4) run, 5) push ups, 6) high knees, 7) sit ups and 8) isometric plank. Count about 15 seconds on each exercise.
- Then students will formulate a hypothesis that predicts which exercise will have the greatest impact on heart rate.
- Next, students will work together to identify the independent variable, dependent variable and constant variables for the inquiry. [IV=Type of exercise, DV=heart rate, and CV=incline, available oxygen, mass...].
- Students will work with teams to conduct the experiment.
- One student from each group should take a Garmin watch, turn it on, and get the associated chest strap.
- Go with the teacher to the restrooms to put on the device - it must fit tight against the skin, at the heart line. Moisten your fingers with a couple drops of water and run it on the back to ensure connection. Successful connection is crucial and may be difficult.

- Verify the heart icon stays on. If troubles persist, repeat the initial pairing process, making sure to allow 3 meters between participants.
- The other students will begin creating a data sheet like the one below.

Hypothesis:

Independent Variable:

Dependent Variable:

Control Variables:

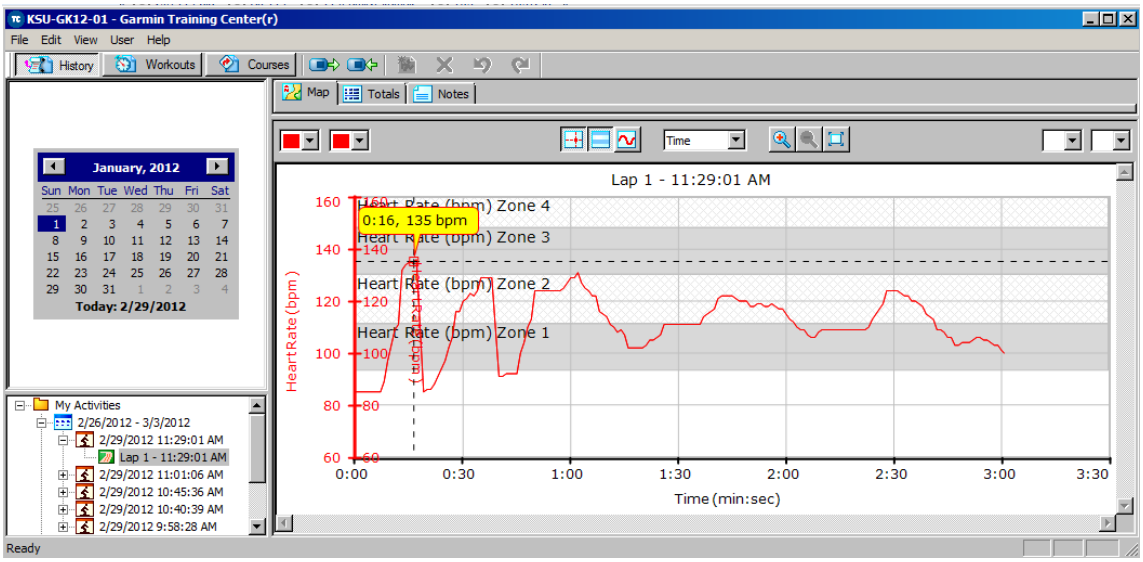
Sample Data Sheet:

Start Timer at beginning and let it run. Begin Exercises every minute (and do each for 15 seconds, then wait 45)

Exercise Number	Exercise Name	Start Time	End Time
1	Jumping Jacks		
2	Squats		
3	Jump rope		
4	Run in place		
5	Push ups		
6	High knees		
7	Sit ups		
8	Isometric Plank		

- Each group will fill in their own hypothesis, variable information, and start and stop records.
- Students will use the heart rate monitors to measure and record their heart rates during each exercise.
- Make sure the heart icon remains constant throughout the experiment. If it is blinking - re attempt the connection as shown above.
- Give the watch to another group member (not the exercise participant.)
- Press mode to get to the main timing window. Timer should be stopped. (If not, press stop.) Press and hold the lap button to reset. Wait until reset is complete. All values should show zero. Record the initial resting heart rate.

- Press start button and have the exerciser begin. The timer should run continuously for the duration of the experiment.
- After 15 seconds, tell the exerciser to stop.
- Wait until the next minute begins.
- At the top of the minute, begin the new exercise. At 15 seconds after. Stop exercising.
- Be sure to record which exercises are associated with which times so you can interpret your graph later.
- When the experiment is complete, one person should bring the watch to the main computer. From the Training Center software, select File / Receive from device. Upload all the data from the watch. The top activity should have the results and plot them automatically.
- Take a screen shot and give it to the students to take to their computer for interpretation. (They will want to find the exercise that gave the highest heart rate.



- **Explain** (5 minutes) - Where is the sensor located? [in the strap] What exactly, is it sensing? [an electrical signal from your heart]
- The heart rate monitor consists of two parts - a transmitter worn around the chest, and a receiver worn on the wrist.
- As the heart beats, an electrical signal is transmitted through the heart muscle in order for it to contract. This electrical activity can be detected through the skin. The transmitter part of the heart rate monitor is placed on the skin around the area that the heart is beating, and picks up this signal. The transmitter then sends an electromagnetic signal containing heart rate

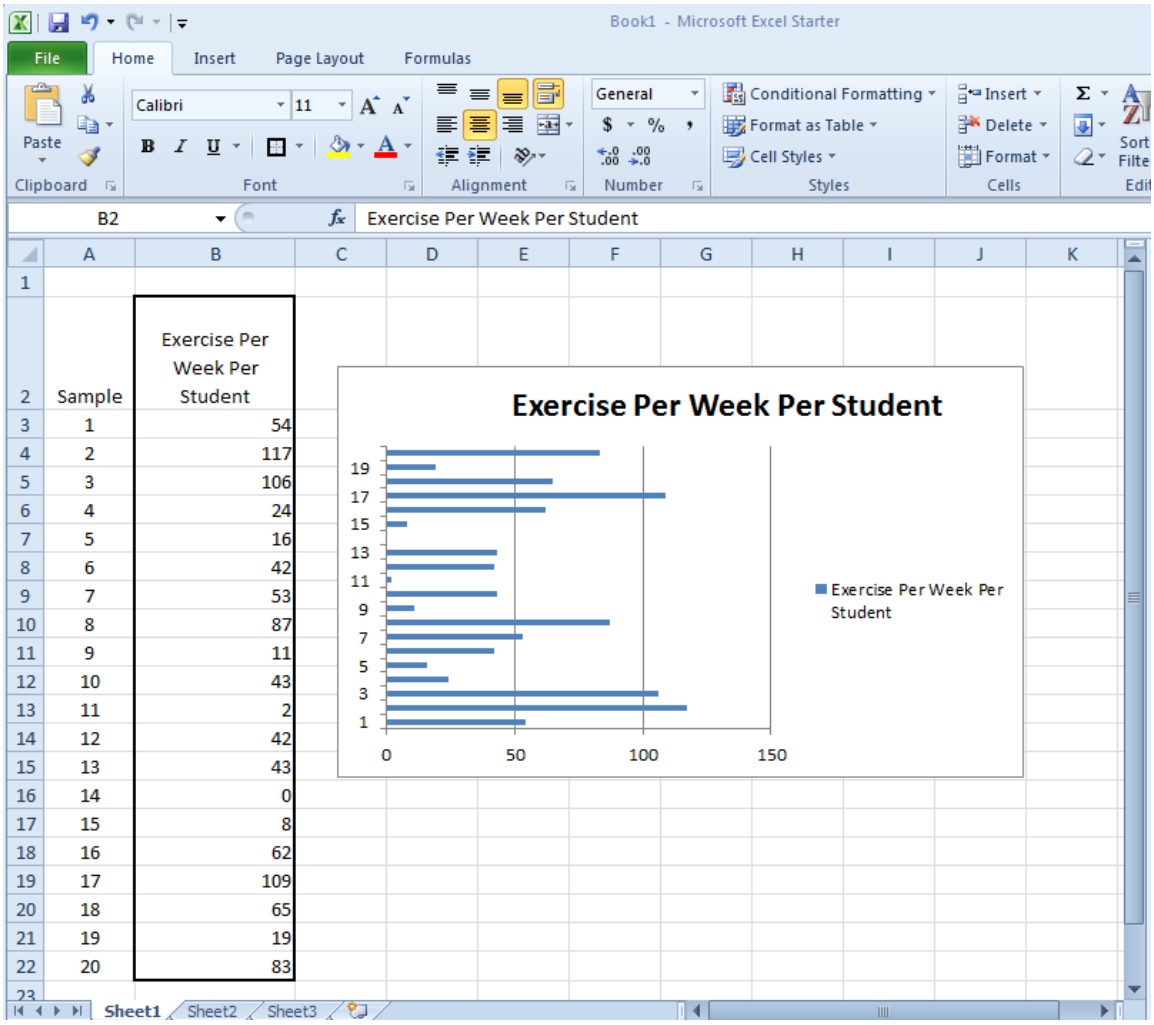
data to the wrist receiver which displays the heart rate.

- Most of us don't think of ourselves as making electricity - would you like to see a visualization of the electrical impulse that the sensor is picking up?
- Video - Heartbeat (1 min)
- We use sensors to measure other things - like concentrations. Concentrations of various substances in our blood are very important. Adding something causes something else to go up or down and we want to keep things at a nice consistent level. This is especially important in diabetes. Does anyone know what that is? [a condition where our blood sugar levels can get dangerously high.] Insulin helps keep the levels low - but you have to be careful. It's easy to measure this - if you can get at their blood to test it. How might you do that? [pricking with a needle] How often? [may be many times a day]. What if - instead of bringing a bit of blood out - we could put the sensor in there? So we did. Notice the common themes of power & programming. The device has battery that needs changing. You are a very fortunate class and have the opportunity to see one of these livesaving devices if you would like. (If you'd rather not, you don't have to look.) :)
- Mrs. Constance can show first the power pack - the display (let them come see) and then - have them trace the lines back to the actual sensor. They may ask questions like How often do you change batteries? Does it hurt? Ask students "Do you know anyone with diabetes? You can ask them how they manage it. Questions like this are great to ask because many conditions tend to "run in families". It'd be good question for a survey. For the next part, we want to come up with some questions for our own class survey.

- **Extend** (10 minutes) - Students will create a class survey with five health related questions (e.g. " how many minutes do kids in our class exercise").
- Brainstorm questions as a group (2 min).
- When time's up, ask for one question from the first group, one from the second, and so on. Now we have classroom survey with a set of questions. Now, we have to answer the questions.
- Next, each group should record their student answers for each question on a different set of paper (5 min).
- When complete, deliver the set of answers to the group responsible for that question.
- Each group should have a full set of results (1 answer per student) for their question.
- *6.SP.1. Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers. For example, “How*

old am I?" is not a statistical question, but "How old are the students in my school?" is a statistical question because one anticipates variability in students' ages.

- **Evaluate** (10 minutes) - Students will graph and interpret the results of the survey using powerpoint or excel graphing software. The type of graph will depend on the question asked.
- A sample graph for the first question may look like the following. If the students enter the data as shown, and highlight cells from B2 through the last cell of data (as shown in the dark box), the students can click "Insert", and pick a 2D bar chart to get the graph. Other options are also valid.
- Students then use the graphs to to qualitatively assess the measure of variability and calculate the mean to evaluate the measure of center for the answers to each question.
- *6.SP.2. Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.*
- *6.SP.3. Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number.*
- *6.SP.4. Display numerical data in plots on a number line, including dot plots, histograms, and box plots.*



Sample	Exercise Per Week Per Student
1	54
2	117
3	106
4	24
5	16
6	42
7	53
8	87
9	11
10	43
11	2
12	42
13	43
14	0
15	8
16	62
17	109
18	65
19	19
20	83

Safety Issues

Moderately strenuous physical activity is required for some participants.

Troubleshooting Tips

Information on Garmin Heart Rate Sensors can be found at: www.garmin.com.

Investigating Questions

“Which type of exercise will raise my heart rate the most?”

Assessment

To evaluate the effectiveness of this unit, a pre-activity assessment is available that can be administered prior to beginning the activity and a post-test is available that can be administered after students have completed the activity.

Attachments

Pre-Activity Quiz
Pre-Activity Quiz with Answers
Post-Activity Quiz
Post-Activity Quiz with Answers
Completed Data Sheet

Additional Multi-Media Support

Artificial limbs with sensors: http://www.wired.com/dangerroom/2012/02/nerve-prosthetics

Smart pills that send you text messages to take your medicine:
http://www.youtube.com/watch?v=9b9SH1LMxbw

> "Smart Pills" embedded with computer chips can help patients stick to their medication regimes in the future. The "Raisin" system, already approved in the EU, has a sensor patch on the patient's skin that communicates with the computer chip swallowed with the pill. The patch will send an SMS message to the patient's phone of they neglect to take their meds. (It's in Chinese, but has subtitles, so you can turn off the sound and explain. The graphics are worth it.)

17-year old creates cancer-killing nanoparticles:
http://www.geek.com/articles/geek-cetera/17-year-old-wins-100k-for-creating-cancer-killing-nanoparticle-2011128/

> Angela Zhang is, and she's just been awarded the $100,000 Grand Prize in the Individual category of the Siemens Competition in Math, Science & Technology. Her project was entitled "Design of Image-guided, Photo-thermal Controlled Drug Releasing Multifunctional Nanosystem for the Treatment of Cancer Stem Cells."
> Her creation is being heralded as a "Swiss army knife of cancer treatment." Zhang managed to develop a nanoparticle that can be delivered to the site of a tumor through the drug salinomycin. Once there it kills the cancer stem cells. However, Zhang went further and included both gold and iron-oxide components, which allow for non-invasive imaging of the site through MRI and Photoacoustics.

Printing living tissues and organs: http://www.youtube.com/watch?v=-RgI_bcETkM

> 3D printing is a technique that is being applied to tissue engineering/regenerative medicine by a number of laboratories. Industrial 3D printers have been available since the 1980s and have traditionally been used for rapid prototyping. In the field of tissue engineering, they are being used to print living tissues/organs with the goal of treating disease and injury with the implantation of these organs. The advantage of this technology is the ability to produce complex geometries in implanted organs that are customized in size and shape to the individual. Someday you may have a printed organ implanted in you!

Implantable florescent glucose sensor:
http://www.slashgear.com/researchers-in-tokyo-working-on-new-fluorescent-implantable-glucose-monitor-19173006/

How does the heart's conduction system work? Electricity in the body
http://www.youtube.com/watch?v=QLDLul1qcWk&feature=fvwrel

Heart beat animation video: http://www.youtube.com/watch?v=AOiyjNFB0as

References

Other

Install Garmin Training Center: URL may change:
http://www8.garmin.com/support/download_details.jsp?id=835

Redirect URL

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*Supporting Program

Kansas State University, Department of Computing and Information Sciences, National Science Foundation GK-12 INSIGHT Program

Pre-Activity Quiz

Post-Activity Quiz

Completed Data Sheet

Hypothesis: *The _____ exercise will cause the highest heart rate.*

Independent Variable: *Type of exercise.*

Dependent Variable: *Heart rate.*

Control Variables: *Mass, temperature, elevation, others*

Sample Data Sheet:

Start Timer at beginning and let it run. Begin Exercises every minute (and do each for 15 seconds, then wait 45)

Exercise Number	Exercise Name	Start Time	End Time
1	Jumping Jacks	00:00	00:15
2	Squats	01:00	01:15
3	Jump rope	02:00	02:15
4	Run in place	03:00	03:15
5	Push ups	04:00	04:15
6	High knees	05:00	05:15
7	Sit ups	06:00	06:15
8	Isometric Plank	07:00	07:15