



5-E CLASSROOM STEM ACTIVITY:
THE SCIENCE BEHIND WORKING OUT

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THE SCIENCE BEHIND WORKING OUT

ANY PHYSICAL ACTIVITY IS BENEFICIAL FOR YOUR BODY, BUT SOME EXERCISES ARE HEALTHIER THAN OTHERS. CHECK OUT THE SCIENCE AND HEALTH FACTS BEHIND SOME OF YOUR FAVORITE WORKOUTS!

BY COURTNEY RUNN

SWIMMING

Calories: Swimming is known as one of the best exercises for burning calories. Because your body is in constant motion, it's a great sport for losing weight or maintaining a healthy figure.

Muscle Building: Swimming builds upper body muscles and strengthens the core. The water provides great resistance, continually building muscle with every stroke and kick.

General Health Benefits: Swimming is a low-impact exercise, which makes it a great complement to other sports and workouts since it lets your body take a break from relying on its own weight. It also is great for heart health because its cardiovascular nature allows the heart to pump blood more efficiently.

Science Spot: Science can not only explain the health benefits behind swimming, but it can also help us understand the basic concept of the sport. It goes hand in hand with Newton's third law of motion which states that an action results in an equal and opposite reaction. So to swim forward, you have to pull the water backward with your hand.

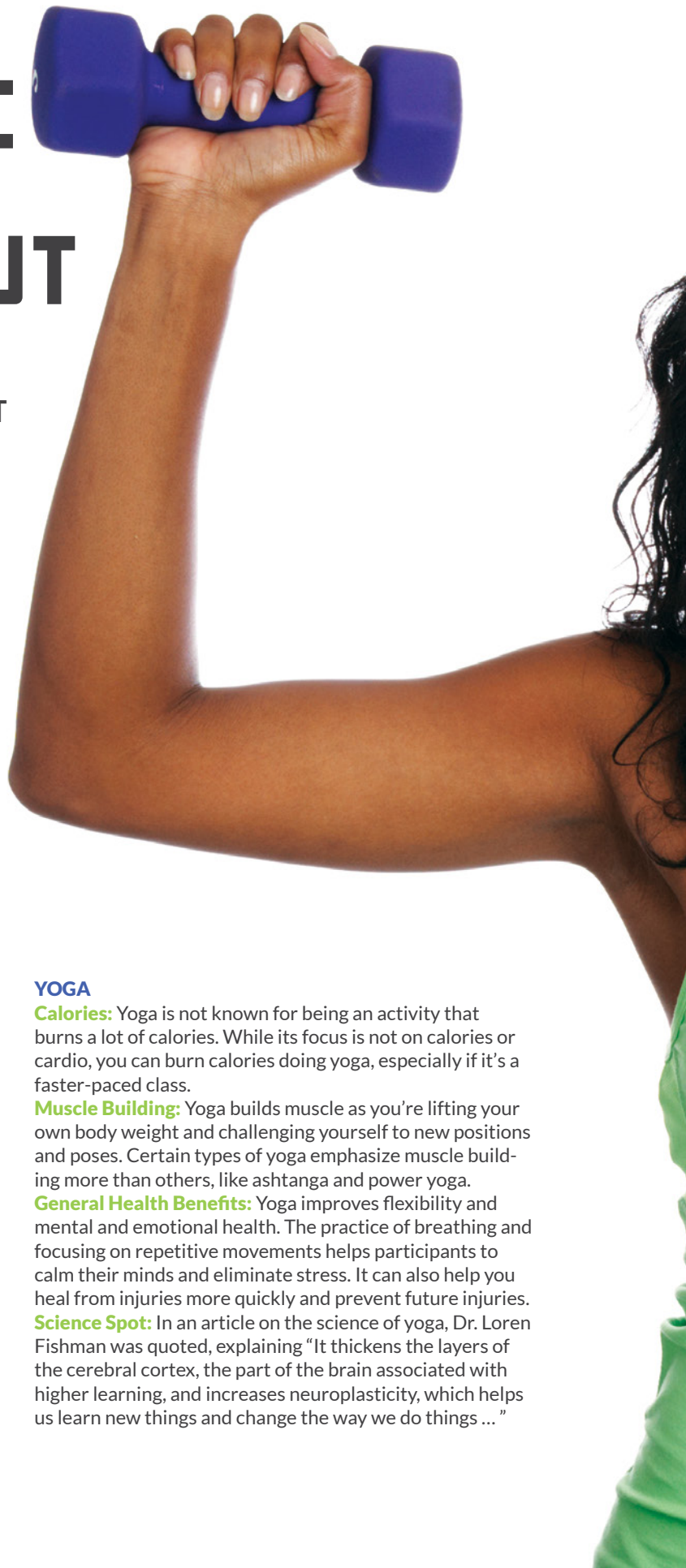
RUNNING

Calories: Running is a great and easy way to workout if you're trying to burn calories. Since you can run virtually anywhere, it's a great option for getting your heart rate up. You also continue to burn calories after you finish running, which is a plus.

Muscle Building: While running might not bulk up your muscles, it will strengthen and challenge them. Running benefits hip extension, hip stability, spinal stability and shoulder flexion.

General Health Benefits: Running can strengthen your knees and joints. While you do have to be careful about the surface you run on and how you pace yourself, the activity actually does help to strengthen you.

Science Spot: Running provides relief for stress and depression. As soon as you start running, your brain is triggered to produce hormones that signal happiness and pleasure, so if you're having a rough day, start exercising!



YOGA

Calories: Yoga is not known for being an activity that burns a lot of calories. While its focus is not on calories or cardio, you can burn calories doing yoga, especially if it's a faster-paced class.

Muscle Building: Yoga builds muscle as you're lifting your own body weight and challenging yourself to new positions and poses. Certain types of yoga emphasize muscle building more than others, like ashtanga and power yoga.

General Health Benefits: Yoga improves flexibility and mental and emotional health. The practice of breathing and focusing on repetitive movements helps participants to calm their minds and eliminate stress. It can also help you heal from injuries more quickly and prevent future injuries.

Science Spot: In an article on the science of yoga, Dr. Loren Fishman was quoted, explaining "It thickens the layers of the cerebral cortex, the part of the brain associated with higher learning, and increases neuroplasticity, which helps us learn new things and change the way we do things ..."




WEIGHT TRAINING

Calories: While weight training is not a cardio exercise, it does boost your metabolism, which allows you to burn more calories throughout the day.

Muscle Building: Weight training mainly focuses on muscle building, but as an exercise. The goal is not to bulk up—that’s reserved for body-builders—but to focus on overall health and grow stronger.

General Health Benefits: Strength training offers great health benefits, including building to endurance, strengthening your joints and increasing strength of connective tissues.

Science Spot: When you lift weights or work out, your muscles are damaged, depending on the intensity of the activity you engaged in. After you finish, your muscles come back together, stronger than ever to face its next test and source of stress.

If you’re interested in learning more about the science behind working out and exercise, consider looking in to personal training or exercise science classes at your school! 

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Here are some ideas for how high school teachers could use this story as a launching point for integrated STEM learning. Our activities follow the 5-E Learning Cycle Model, and the activity below is intended to last three to four 1-hour class periods (although portions of the activity could be used in shorter time periods).



Part 1: Engage

- ① Have students read the STEM JobsSM article: “The Science Behind Working Out.”
- ② Discuss the article with students, posing questions like:
 - What does it mean to work out?
 - How do we know when we are working out and how do we measure it?
 - What science concepts have we learned that are relevant to exercise and weight gain or loss?
 - How do we actually lose weight and where does it go?
- ③ Watch Ruben Meerman’s TED talk on the mathematics of weight loss (or a portion of it): youtu.be/vullIsN32WaE
- ④ Pose additional questions to students, like:
 - In summary, what does it mean to “breathe out fat?”
 - What are some of the equations that Ruben mentioned during his presentation?
 - What data did Ruben share that you found most interesting?
 - How does math relate to our health?



Part 2: Explore

- ① Place students in groups of 3-4 and give groups the following task:

$$\text{RMR (Female)} = 248 \times m(0.4356) - (5.09 \times a)$$

$$\text{RMR (Male)} = 293 \times m(0.4330) - (5.92 \times a)$$

Today, your group will be working as a personal trainer. You have a client (it can be one person in your group or you may use the information provided below. You need to devise an exercise plan to help the client reach their weight loss / weight gain / weight maintenance goal. Your exercise plan will include the following based on the information you are provided:

Client Current Weight: 158 pounds

Client Current Height: 5'7"

Client Sex: Select one and circle it: (M / F)

Client Age: Choose an age from 18 - 45 _____

Client Weekly Weight Goal Circle one: +2 lbs Maintain Current Weight -2 lbs

You burn most of your daily calories with little to no conscious effort. Whether you’re talking on the phone, working at a keyboard or just watching television, your body is consuming energy to keep your heart pumping, your lungs breathing and your organs functioning. The calories used to maintain these basic bodily functions add up to your basal metabolic rate, or BMR. Basal essentially means base—think of it as the number of calories that’s just enough to cover all your body’s bases.

60 to 75 percent of the total calories we expend each day require no physical activity at all. Knowing your BMR can help you create a more effective strategy for weight management and to create an effective exercise program.

The easiest way to measure your BMR is to use an online calculator. These calculators factor in your height, weight, gender and age, then assess how many calories you need to eat daily just to maintain your current weight at rest.

You can do the math yourself, using the appropriate equation:

- If you're a man, your BMR is equal to: $66 + (6.23 \times \text{weight in pounds}) + (12.7 \times \text{height in inches}) - (6.8 \times \text{age in years})$.
 - Example, if you're 170 pounds, 5'11" and 43, your BMR is $66 + (6.23 \times 170) + (12.7 \times 71) - (6.8 \times 43) = 1,734.4$ calories.
- If you're a woman, your BMR is equal to: $655 + (4.35 \times \text{weight in pounds}) + (4.7 \times \text{height in inches}) - (4.7 \times \text{age in years})$.
 - Example, if you're 130 pounds, 5'3", and 36, your BMR is $655 + (4.35 \times 130) + (4.7 \times 63) - (4.7 \times 36) = 1,357.4$ calories.

Next, figure out your total daily caloric requirement by multiplying your BMR by your level of activity:

- If you rarely exercise, multiply your BMR by 1.2
- If you exercise on 1 to 3 days per week, multiply your BMR by 1.375
- If you exercise on 3 to 5 days per week, multiply your BMR by 1.55
- If you exercise 6 to 7 days per week, multiply your BMR by 1.725
- If you exercise every day and have a physical job or if you often exercise twice a day, multiply your BMR by 1.9

If the man in the example exercises 3 days a week, his daily caloric requirement is $1,734.4 \times 1.55$, or 2,688.3 calories.

If the woman in the example exercises 6 days a week, her daily caloric requirement is $1,357.4 \times 1.725$ or 2,342.5 calories.

This calculation gives you the number of calories you burn in one day at your current level of activity; this is the number of calories it takes to stay at the weight you are if you don't change anything.

The energy required to expend (lose) one pound of body fat is 3,500 Calories

- I) Using the calculations above, and the information provided for your client, determine the following:
 - A) What is your client's BMR?
 - B) Given your client's weight management goal, how many calories do they need to expend per week? Per day?
 - C) Given your client's weight management goal, how many calories should they consume per week? Per day?
 - D) Given your client's BMR, how many calories must they expend per day through exercise?
- II) Research exercise options and average calorie expenditure per exercise type and the time required.
 - A) Your client wants options—how long would they have to run to reach their daily exercise goals? How long would they have to walk or swim or lift weights?
- III) Create a daily meal and exercise chart with recommendations for your client to assist them in reaching their goals.
 - A) For extra credit, research the additional effects that some calories like simple sugars have on weight management and health.
- IV) Identify additional health risks associated with your plan.
 - A) ie. extreme exercise as weight management, starvation as weight management, single food type or limited food selection, etc.

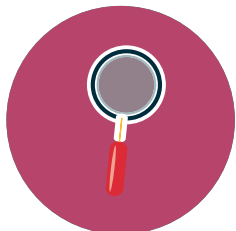
Once you've finalized the materials and roles for your presentation, you can present them to the class or capture the presentation using a camera, phone or iPad.

Circulate and assist student groups as they lay out their plans and identify exercise plans and dietary strategies they will recommend. Reinforce that the presentation does not have to be perfect, and that they should focus on investigating the properties of types of physical exercise and the mathematical relationships between exercise and weight management.



Part 3: Explain

- ① Have students present their plans to the class. Encourage students to give feedback to the other groups on their presentation.
- ② Discuss the similarities and differences between strategies with the class. Categorize each exercise type, the goals students were trying to achieve and the strategies they employed.
- ③ Engage students in discussing scientific principles involved in their project and how mathematics, physics, biology and chemistry concepts play various roles in achieving desired outcomes.



Part 4: Elaborate

- ① Have student groups investigate other types of food styling challenges:
 - I) Have students calculate their own exercise requirements and research and determine appropriate exercise strategies with the following constraints:
 - A) You have only one hour each day to exercise.
 - B) You only have access to processed and prepared foods.
 - C) You have to estimate food calories.
 - D) Given that professionals recommend that you gain or lose no more than 2 lbs per week, what if you have longer term goals such as losing 20 lbs?
 - E) What risks do people face when they eat and exercise without considering the mathematics of weight management?
 - F) Investigate and review the chemical equation of fat loss as explained by Ruben in the provided video.

There are a variety of web resources for students to investigate—here are a few—but encourage your students to discover and share others:

This is a survey that students can take a share:

docs.google.com/forms/d/1kLxXM9CYoZbSa3KxfBnzhyox5r96qI2YTphylv_qyok/viewform

Luke Durward's Ted Talk about encouraging his brother to exercise and make healthy choices:

youtu.be/Q4yUIJV31Rk



Part 5: Evaluate

Have each student summarize their experience (or journal) with notes about how concepts in mathematics are relevant to exercise and weight management. Ask them to record at least three specific examples from either videos they watched or the presentations they made.

Common Core Math Standards:

CCSS.Math.Practice.MP3. Construct viable arguments and critique the reasoning of others.

CCSS.Math.Content.HSN.Q.A.2. Define appropriate quantities for the purpose of descriptive modeling.

Next Generation Science Standards:

HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability and aesthetics as well as possible social, cultural and environmental impacts.