The Scientific Method—Eureqa!

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This curriculum unit is recommended for:
Fifth Grade Science and Mathematics

Keywords: Scientific Method, Genetic Algorithms, Speed, Eureqa, Artificial Intelligence, fifth grade, math, science

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit.

Synopsis: This curriculum unit is intended to entice students about the math and science work they will do throughout the year. Students will begin with a lesson on the Scientific Method and explore how to put this process to work in an experiment of their own. "*The Scientific Method—Eureqa!"* uses Eureqa, a genetic algorithm based software program, that mines through data to find specific patterns and optimal solutions to problems. Use of this software is typically used in corporate offices or higher education facilities, however in this unit it is relatively "fifth grade friendly". Students have the opportunity to see just how hard a scientist works to prove his or her discoveries, as well as the influence mathematics and the sciences have on each other.

I plan to teach this unit during the coming year to 45 students in a fifth grade Science course.

I give permission for the Institute to publish my curriculum unit and synopsis in print and online. I understand that I will be credited as the author of my work.

The Scientific Method—"Eureqa"!

Katelyn Gardepe

Rationale

As soon as I had the chance to conduct research in the field of Artificial Intelligence, I jumped on it. In this new age of technology, it is such a significant part of our everyday life. Everything we do throughout the day is based on some form of Artificial Intelligence whether we pay it any attention or not. Technology is taking over our society- from cell phones with "Siri", to cars that park themselves, to internet searches that finish themselves. Artificial Intelligence is fast growing and significant to each and every one of us.

Technology is finding a variety of ways to intrigue our every wonder. Creating inventions we would have never dreamed of, like Google's self-driving car, and computerized robots that can fulfill duties almost identical to a human being (if not better, in some cases). It is a subject that is continually changing, growing, and taking over.

For these reasons, I had no doubt in my mind that this was an excellent topic to integrate into my daily instruction with students. While my students seem to enjoy Science much more than most other subjects, it can sometimes be tough to grab their attention with certain topics. Using artificial intelligence as a driving topic would surely intrigue my fifth graders!

Student Background/ Demographics

Many of my students come from low-income homes or undesirable circumstances. My school is located in a large, urban area of Charlotte, North Carolina. The Charlotte-Mecklenburg school district is quite large with 164 schools total. My school is a K-5 elementary school and is made up of approximately 900 students, 76% of which are African American. This year, the average class size is about 20-22 students. Our school is not considered Title 1, however it is considered economically disadvantaged. In 2013-2014 we had approximately 65% of our students who qualified for free and reduced lunch services. As a district, approximately 54% of all of our students qualify for free and reduced lunch, meaning their families made incomes that fell below the poverty line. This year, all of our students are given free breakfast and lunch due to our school demographics.

We often struggle with resources because a lot of our families cannot afford them and we are not funded as a Title 1 school. Our school qualifies for an amazing program called Classroom Central which collects school supply donations and houses them at their warehouse. Teachers at qualifying schools can shop at Classroom Central for free supplies for their students. Without the help of this program, we often find ourselves buying supplies or just a few families that are able to contribute.

As far as the curriculum goes, we often scrounge for our own resources. We utilize the internet and old resources to supplement the curriculum we have received for our students to follow. It can often be tough to complete certain experiments with our students because of the lack of resources. My classroom is blessed with 10 student iPads from a grant we won a few years back. Often we will utilize these to work on Discovery Education explorations or other interactive labs.

In poverty-stricken households, children often hear way more negativity than they do positivity. It is my goal as a teacher, and with this unit, to intrigue my students about science and let them know that they can do anything they put their mind to! For this reason, my unit will focus on what it means to be a great scientist, utilizing the scientific method to solve problems, and how genetic algorithms are being used to take science to the next level.

Background

The NC Essential Standards and End-of-Grade Test focus strongly on the ideas behind Force and Motion. Because of this, my unit will include experiments based on the physics behind some of Newton's Laws. Students will need to have at least a brief knowledge of some important vocabulary and ideas.

Scientific Method

To begin, students should understand the steps that the Scientific Method is comprised of. This can be explained in a lesson prior to starting the unit if students have not previously been exposed. The first activity in this unit will give them a brief overview of these steps. While I have seen a few different variations of the steps to the Scientific Method, I teach my students that there are 5 essential steps:

Make Observations- Making observations acts as the initial step of the Scientific Method. This is where the inspiration for our experiment comes into play. By observing things around us, we can then form a question or problem that we would like to know more about. The question or problem should be just that, the question or problem the students are trying to solve. Students should understand that scientists can create an experiment based on pretty much any question they have ever wondered about. Great scientists explore, explore, explore!

Form a Hypothesis- A hypothesis is an educated guess or prediction of what the answer to their "question" is. For instance, in my classroom, we have conducted a lab we call the "Matchbox Car Lab". This lab requires students to test a matchbox car on two different surfaces (carpet and tile). If the question is, "On which surface will the matchbox car go the furthest distance?" the student would create a hypothesis with their prediction. Students might say, "*I think the matchbox car will go further on the carpet than the tile*" or "*I think the matchbox car will go a further distance on the tile than the carpet"*.

Designing the Experiment/ Procedure- After making observations and forming a hypothesis about the question we are trying to solve, we now need to design an experiment that will test out our hypothesis. Once we create an experiment, we will create an exact procedure to follow along the way. The procedure would include the steps the scientist will take to complete the experiment. For the lab mentioned above, the procedure would be as follows:

1. Students will set the car on a given line on the surface.
2. Then, another student will pull a rubber band back to a different given line on the floor (usually about 5 inches back from the first line) and release the rubber band.
3. Students will measure the distance the car has traveled with a yard stick.
4. Record your data on your lab sheet.

It is very important that students understand the significance of this part of the scientific method. This is where we will begin our experiment and the procedure must be followed precisely each time it is conducted. If students stray from the original procedure for even just one trial our data will not be accurate.

Collecting data/observations- Now that the students have designed and begun to conduct the experiment, it is time to collect data. Students will collect data and record the data in their notebooks or on their lab sheets. Students will naturally make some observations of what they see during this time, as well as after.

Analyzing Results/ Conclusion- After completing the experiment, we can take a better look at the data that we have collected. You can encourage students to display their data in an organized representation such as a table or graph. For some experiments, this will help students to correctly identify trends and make further predictions. Students should use the data to draw conclusions about their original question at hand. Conclusions should not only provide an answer to our given question, but also reflect on the earlier-created hypothesis.

Force and Motion

Force and Motion is a large piece of the 5th grade science curriculum. The North Carolina Essential Standards require students to:

1. Explain how factors such as gravity, friction, and change in mass affect the motion of objects.
2. Infer the motion of objects in terms of how far they travel in a certain amount of time and the direction in which they travel.
3. Illustrate the motion of an object in a graph to show a change in position over a period of time.
4. Predict the effect of a given force or change of mass on an object's motion.

Vocabulary

While students have a small amount of exposure to these ideas in the fourth grade, there is much more vocabulary that they will need in order to understand Force and Motion at the fifth grade level.

Acceleration: Change in velocity.

Action: The force one object applies to a second, as in Newton's third law of motion, which states *"for every action, there is an equal but opposite reaction"*.

Balanced Forces: When the two forces being applied to an object are equal and thus cancel each other out.

Distance: An interval of measurement between two points of time.

Force: A push or pull on an object, causing a change in motion.

Friction: A force that opposes the movement of one object passing another.

Gravity: The force that attracts an object towards the center of the earth.

Inertia: The tendency of an object to resist change in motion (as in Newton's First Law).

Mass: The amount of matter that is in an object.

Matter: Anything which occupies space and has a mass.

Motion: When an object changes position

Reaction: The force with which an object responds to an action.

Speed: How fast an object's position changes with time

Unbalanced Forces: When two forces acting on an object are not equal. One force is greater than the other, and thus would apply the greater force to the object.

Velocity: The speed of an object along with its direction of travel

Work: The use of force to move an object or change its position

Newton's Laws of Motion

Isaac Newton came up with three laws of motion with which we define most all aspects of Force and Motion. They are as follows:

Newton's First Law of Motion: An object at rest tends to stay at rest and an object in motion tends to stay in motion, unless a force acts upon it.

Newton's Second Law of Motion: Acceleration is produced when a force acts on an object. The more mass the object being acted on has, the more force it will take to make it accelerate.

Newton's Third Law of Motion: For every action there is an equal and opposite reaction. This means that when a force is applied to an object, there will be a reaction of equal force created from that object. Think of it as bumping into someone else. The force from your body pushes the other person which then creates a force from that person which could potentially bump into someone or something.

Students will utilize their knowledge of this vocabulary to apply the scientific method and complete an experiment about speed. Following data collection, students will be asked to create some predictions based on this data. To encourage critical thinking and standards of mathematical practice, students will make an effort to identify the relationship between their data sets. For instance, since our lab will cover speed, can students identify that the relationship between the three data points (speed, distance, and time) is Speed = Distance ÷ Time? We will discuss Newton's Laws and how scientists discover these types of relationships. This will lead us into our next topic of genetic algorithms.

Genetic Algorithms

Genetic algorithms are algorithms that are based on Charles Darwin's Theory of Evolution. Centuries ago, Darwin concluded that all human life came from an individual ancestor. He believed that as time went on, "natural selection" occurred. Natural selection is a form of "survival of the fittest". The idea is that as new life is created, only the most advantageous genes or traits are passed down to offspring. Parts of the population that hold disadvantageous traits would not reproduce and eventually die off. If this theory is true, natural selection would continually create a better, stronger, "fitter" individual than the previous generation had.

So what exactly do we mean when we say "fit"? As a fundamental part of natural selection, after a population is identified, each individual is given a "fitness score". This fitness score represents how well the individual is adapted to its environment. For instance, we could look at a problem called, "The Knapsack Problem". Used in the early

works of mathematician George Dantzig, the knapsack problem attempts to solve a dilemma with optimization. You are given a knapsack in which you may pack several items. Each item is labeled with a value (based on its value to the given situation) and a weight. The knapsack may not weigh over 7 pounds (or a given weight you decide), but optimally you would want to include the highest value of items. For a better understanding, let's take a look at this diagram:

Knapsack Problem Diagram

Pretend that you are headed on a camping trip in the wilderness. You want to bring the items that will provide you with the most value, but stay within the weight requirement of 7 pounds. (Remember that as we work with this problem, the "value" has nothing to do with nutritional value, but is rather a measure of the utility of the object.) Here are the items you have to choose from:

Apple 

Raisins 

Bananas 

Grapes 

Watermelon 

Peanuts 

For this problem, the item values and weights are arbitrarily chosen and are given for you below. We will now use this data to find the combination that maximizes the value of the chosen items while staying under our given weight limit.

Item	Apple	Raisins	Banana	Grapes	Watermelon	Peanuts
Weight	1	2	2	1	1	1
Value	9	8	10	12	11	7

Now we will generate a random solution. We will roll a die to determine which items get picked. If the dice lands on an even number it will be a "yes", meaning we will take the item with us, if we roll an odd number it will be a "no" meaning we won't take the item. We will do this 6 times.

After we determine whether the item is a yes or no, we will add up the item value and weight for each yes. This sum of the values for each item will become our fitness score. Our goal is to find a combination that will give us a weight of 7 pounds or less, with the highest value. The scores that are below or equal to 7 pounds and have the highest values will be our "fittest" combinations for our Knapsack problem.

Trial #1: Total Weight: **8** Total Value: **37**

Item	Apple	Raisins	Banana	Grapes	Watermelon	Peanuts
Weight	1	2	2	1	1	3

Value	9	8	10	12	11	7
Yes or No	no	yes	yes	yes	no	yes

For example, for Trial #1 we rolled a yes for the raisins, banana, grapes, and peanuts. The weight of the raisins is 2, the banana weighs 2, the weight of the grapes is 1, and the peanuts weigh 3. If we add these values together we get a weight of 8. The value of the raisins is 8, the banana is 10, the grapes are 12, and the peanuts are 7. If we add these values together, we get a combined value of 37. We will do the same for the following trials.

Trial #2: Total Weight: **4** Total Value: **33**

Item	Apple	Raisins	Banana	Grapes	Watermelon	Peanuts
Weight	1	2	2	1	1	3
Value	9	8	10	12	11	7
Yes or No	no	no	yes	yes	yes	no

Trial #3: Total Weight: **9** Total Value: **46**

Item	Apple	Raisins	Banana	Grapes	Watermelon	Peanuts
Weight	1	2	2	1	1	3
Value	9	8	10	12	11	7
Yes or No	yes	yes	yes	yes	no	yes

Trial #4: Total Weight: **5** Total Value: **42**

Item	Apple	Raisins	Banana	Grapes	Watermelon	Peanuts
Weight	1	2	2	1	1	3
Value	9	8	10	12	11	7
Yes or No	yes	no	yes	yes	yes	no

Trial #5: Total Weight: **8** Total Value: **34**

Item	Apple	Raisins	Banana	Grapes	Watermelon	Peanuts
Weight	1	2	2	1	1	3
Value	9	8	10	12	11	7
Yes or No	yes	yes	yes	no	no	yes

Trial #6: Total Weight: **6** Total Value: **41**

Item	Apple	Raisins	Banana	Grapes	Watermelon	Peanuts
Weight	1	2	2	1	1	3

Value	9	8	10	12	11	7
Yes or No	no	yes	yes	yes	yes	no

Now that we have figured out a few fitness scores, let's move on. Our goal was to find the combination of items which will give us a weight of 7 pounds or less. The trials with the highest values, weighing less than or equal to 7 pounds, will be the ones that "reproduce". The trials with weights of more than 7 pounds do not fit the criteria and will "die off". See the table below to easily view the trial values.

Trial	**1**	**2**	**3**	**4**	**5**	**6**
Weight	**8**	**4**	**8**	**5**	**8**	**6**
Value	**37**	**33**	**46**	**42**	**34**	**41**

Because Trials 1, 3, and 5 all had weights that were greater than 7 pounds, they are not fit for our problem. I have crossed them out because essentially they will not reproduce and will die off.

Now we will look at the trials which kept our solution under our weight constraint, but gave us the highest value. Trial # 4 had a weight of 5 pounds and a value of 42. Trial #6 had a weight of 6 pounds and gave us a value of 41. Optimally, the trials with the highest values, under the weight restraint would be most "fit". With this said, Trial #4 and #6 would be our "fittest" solutions. The two of these trials (#4 and #6) will now "reproduce".

Trial #4:

Total Weight: **5** Total Value: **42**

Item	Apple	Raisins	Banana	Grapes	Watermelon	Peanuts
Weight	1	2	2	1	1	3
Value	9	8	10	12	11	7
Yes or No	**yes**	no	yes	yes	yes	no

Trial #6:

Total Weight: **6** Total Value: **41**

Item	Apple	Raisins	Banana	Grapes	Watermelon	Peanuts
Weight	1	2	2	1	1	3
Value	9	8	10	12	11	7
Yes or No	no	**yes**	**yes**	**yes**	**yes**	**no**

Now, we will roll a die to determine the position at which the chromosome (or trial) will be split. I have done this for us and have rolled a 1. This means we will split both

chromosomes after the first item. However, if I randomly rolled a 2, we would split each chromosome after the second item, leaving two items on one side of the split and 4 items on the other side of the split. In our case though, we will take the first item of Trial #4 and combine it with the last five items of Trial #6 like this:

First part of Trial #4

New Weight: **7** New Value: **50**

Item	Apple	Raisins	Banana	Grapes	Watermelon	Peanuts
Weight	1	2	2	1	1	1
Value	9	8	10	12	11	7
Yes or No	**yes**	**yes**	**yes**	**yes**	**yes**	**no**

Second part of Trial #6

Then, we will do the same thing again. This time, we will combine the second part of Trial #4 with the first part of Trial #6, like so:

Trial #4:

Item	Apple	Raisins	Banana	Grapes	Watermelon	Peanuts
Weight	1	2	2	1	1	1
Value	9	8	10	12	11	7
Yes or No	yes	**no**	**yes**	**yes**	**yes**	**no**

Trial #6:

Item	Apple	Raisins	Banana	Grapes	Watermelon	Peanuts
Weight	1	2	2	1	1	1
Value	9	8	10	12	11	7
Yes or No	**no**	yes	yes	yes	yes	no

Once combined, our solution will look like this:

New Weight: **4** New Value: **33**

First part of Trial #6

Item	Apple	Raisins	Banana	Grapes	Watermelon	Peanuts
Weight	1	2	2	1	1	1
Value	9	8	10	12	11	7
Yes or No	**no**	**no**	**yes**	**yes**	**yes**	**no**

Second part of Trial #4

This process would continue with the first part and second part of each new trial being combined. The idea is that as we continue to combine the "fittest" models of this

problem, all of the unfit models will die off and we will continue to produce even more fit models as we continue down the road.

The idea of a genetic algorithm (GA) is demonstrated well by the diagram above. The Knapsack Problem could be solved in a variety of ways, but this is a genetic algorithm based approach. This idea of GA's can be applied to an array of similar optimization problems as well, like finding the best hypothesis for a given set of data. Genetic algorithms utilize a form of natural selection to weed out the "unfit" relationships between data. After some random selections, we only kept the solutions which provided us with the highest value and a weight of less than or equal to7 pounds. All other solutions had been discarded, or if you refer back to the theory of evolution, they have "died off". The solutions that were most fit, then went ahead to reproduce. Similar to our genetic make-up, a random selection of Trial #4 was combined with the other part of Trial #6 to then create a new, "fitter" solution. Similarly, if there were other solutions that were "fit" for our problem, they would also do this and create a fitter solution. As this continues to happen, only the solutions which are best fit to the problem will survive. Thus, our solution to the problem is slowly becoming more and more perfected!

Eureqa

Thanks to our growing world of Artificial Intelligence, scientists now have some help… in the form of a robot scientist, of course. *Eureqa* (created by Nutonian Inc.) is an easy-to-use software program that utilizes genetic algorithms to find patterns in data. The new technology will mine the data it is given to find complex relationships and mathematical patterns. When given problems that took years for scientist like Isaac Newton to solve, *Eureqa* is said to have found solutions within hours.

Throughout this unit, students will conduct a variety of experiments and collect numerous sets of data. Students will be asked to infer the relationship between their data sets and then explore further as to what they mean. We will utilize *Eureqa*, the robot scientist, to test out our data and dig deep into how scientists like Isaac Newton have formulated these relationships on their own. It is my hope that students not only see the importance of science and discovery, but also of mathematics and its application.

Teaching Strategies

Students will use a variety of strategies throughout this unit. These strategies will be used to recall prior knowledge and also ignite interest in the present knowledge students are about to learn.

Note Taking

Students will use their Science notebook to take notes throughout the unit. This is important for students at the fifth grade level because as they progress in their schooling they will have to learn to identify the important information versus the unimportant.

Lab Reports

In all subjects, it is important for students to be able to organize their thoughts throughout a lesson. To piggy back on the note taking, students will use lab sheets to create organized lab reports for their experiments. This will help to keep all of our information in one place and allow students to easily draw conclusions at the end of our lab.

KWL Charts

KWL charts are used in many classrooms. This is an opportunity at the beginning of a new lesson to allow students to show what they know. As a student and a teacher, this is a great strategy because it gives students a time to reflect and recall prior knowledge about the topic you are going to study. As a teacher, this gives you a better idea of what the students still need to learn and what they are eager to learn about the topic.

Videos

Students will watch short videos to engage them in the Scientific Method. I use Study Jams (www.studyjams.com) a lot with my students and they love it. The videos are always very informative, but also short and to the point. They give just enough to spark the interest of the child and lead into a lesson on the topic.

Activity Sorts

I love the idea of sorts! It is an activity that reaches many different learning styles and allows all students to get involved. Students are often moving around and engaged in conversation with one another to figure out where each piece of the sort should go. It gives them the opportunity to advocate for their thoughts and prove to others why information is correct or incorrect.

Task Cards

In this unit, we will use formula task cards to attempt to determine a mathematical formula for our data. Task cards are another great way to give a hands-on, group activity for students. It is a much better alternative to a standard worksheet.

Labs

Students love conducting experiments! Labs are a great way to engage students and teach new concepts at the same time. This form of discovery accommodates many different learning styles and is always a great addition to any lesson.

Classroom Activities

Activity #1: What is the Scientific Method?

For this first activity, students will be discussing the job of a scientist, what it means to be a good scientist, and the scientific method. Begin with a K-W-L chart about Science and Scientists. Ask students what they know about the job of a scientist and what they would like to learn more about. Discuss the idea that scientists often try to answer questions many people are curious about. To do this, they utilize the Scientific Method. Discuss the scientific method and what students might know about it already. Ask students when they have used the scientific method in the past and how it helped them to answer a question of their own.

After this discussion, there is a great video on the Scientific Method on www.studyjams.com. It is less than 5 minutes long and shows the Scientific Method in action. This will engage students and ignite their interest for conducting their own experiments this week. When the video is complete, have students take notes on the 5 essential steps of the Scientific Method in their notebook.

Activity #2: Scientific Method Sort

In this activity, students will complete the Scientific Method sort. Review the steps to the Scientific Method before breaking students into groups of 3 or 4. Then, have students read through the task cards and match each task with the correct part of the scientific method where it would take place. When all students have finished, discuss as a class. Ask students if they have thought of any questions they might want to answer with an experiment? (See Sort Cards attached below)

Activity #3: Marble Lab

Today we are going to complete a lab that has to do with calculating speed. However, students have probably not yet been introduced to many Force and Motion concepts yet and that is okay. DO NOT GIVE THE STUDENTS THE FORMULA FOR SPEED AT THIS TIME. Following the lab, students will work to try and derive the formula on their own based on the data they have collected. If you give them the formula now, it will defeat the purpose of today's activity. (* As you complete the lab, keep in mind that students will use the data collected to determine the formula for speed. The simpler the data is, the easier it will be to figure this out. With that said, as you tell students the time it took the marble to travel, I would round them so that they will be easy to compute with later on.)

For this lab, we are going to roll a marble down a tube and see just how fast it will go. The tube will be tested at different angles and students will have to decide which angle the marble will travel the fastest. You should conduct the experiment as a class having students come to the front to help and then allow students to try it out themselves. You will need 2 empty wrapping paper tubes taped together, a marble, a stopwatch, a ruler, and note taking materials. (Lab Template attached below)

Students should begin to fill out the lab sheet provided with our observation/question and also a hypothesis. Then, discuss the experiment and fill in the correct information on their lab sheet. Refer to the sample lab sheet for materials needed, procedure, and more.

You will try the experiment at two different positions. Your first position will require 8 textbooks stacked on top of each other. Using the floor as your starting point, pick up the other end of the tube so that it is sitting on the top of the textbook pile you have made. Measure the wrapping paper tube with a ruler or yard stick and record the data on the board. Next, you will roll the marble down the tube while someone else uses the stopwatch to time it. (The person keeping the time will have to be very quick—it might be a good idea for you to do this and a student to drop the marble.) Record the time it took to travel the distance of the tube and repeat for 3 trials.

Then, take textbooks away from your pile so that there are only 3 left. Ask students if they think that marble will travel faster down this tube and why. Repeat the experiment and record the data.

Be sure that students have completed their lab sheet with today's information. They will not yet be able to finish their data or conclusion. Tomorrow we will discuss how to find the speed of a moving object.

Activity #4: Science and Math – We go together!

Tell students that yesterday we took a guess as to which trial the marble would travel faster, but scientists need to prove their work. Often in Science, we use mathematical formulas to describe relationships and make predictions. In order for us to determine the exact speed of the marble, we will need to use two different factors that we used in our experiment yesterday. (You can throw it out there and see if the students can determine this from the lab.) Tell students that we will use distance and time to determine the speed. Discuss that for this particular lab, the distance traveled will be the length of the wrapping paper tube, and the time would be how long the marble took to travel from the top of the tube to the floor.

You will need to compute the speed for at least one of the trials to give to students. Write this information on the board: Distance: _____ Time: _____ Speed: _____ and fill in for the students. Then, give students the formula task cards provided and a calculator (depending on the complexity of your data). Tell students that they will need to use our data and insert it into each of the formula cards given. Students will try to determine which formula best fits their data (which formula represents speed).

As students begin to work on this, chances are that most of the formulas will not work for the data and some will give them an answer that is relatively close to the speed we have determined. After about 10 minutes, stop students and direct them to start putting aside formulas that are "close" to the data and getting rid of formulas that do not seem to

fit our data at all. It is the intention that the Distance ÷ Time formula will be the closest fit, but others may also be close.

Discuss student findings after about 20 minutes. Share with students that science and math are so closely related. Great scientists like Isaac Newton, who actually derived the formula for speed, spent many years working with very complex data to determine this calculation.

Activity #5: Modern Day- Robot Scientists!

Review with students the time it took them to determine the formula for speed yesterday. Discuss trials and tribulations of the activity and ask the students to remember that this is one of the many processes a scientist has to go through to prove theories and ideas.

Today, you will introduce students to the Eureqa software. Briefly discuss how students think our world has changed since you were in school. (Of course, we are going to become ancient in a matter of seconds… be ready!) Students will most likely talk about technological advances like phones and tablets. If not, steer them in this direction. Explain to students that as our world changes and we continue to advance in the field of artificial intelligence, technology has begun to fight some of these battles for scientists.

Show students how Eureqa works using a Smart board or a projector for the class to see. Insert the data from yesterday's lab and let the software work its magic. Because the data is rather simple, the software should not take long. However, let students know that with more complex data, this software could take months to derive a formula. Discuss the process of Eureqa and how it utilizes genetic algorithms to pick up on patterns in data (mentioned in the Background section of this unit).

Let students try it out themselves. Give students the data on the board for the second part of yesterday's experiment (using only 3 textbooks). Let students insert the data and see if the software will derive the formula for speed.

At the completion of this activity, students should be able to complete their lab sheet with all data points and a conclusion.

Scientific Method Sort

<table>
<tr><td>Making Observations</td><td>Forming a Hypothesis</td></tr>
<tr><td>Designing an Experiment</td><td>Collecting Data</td></tr>
<tr><td>Drawing Conclusions</td><td>Catherine watches the other kids in the lunch line get their lunch. It seems like all of the student who are getting pizza are also not getting any fruit or vegetables with their meals. Catherine wonders if this is really the case.</td></tr>
<tr><td>Ms. Gardepe is going to give the same test to two different classes that she teaches. After being taught the exact same lessons, one class will test on Friday before the weekend begins. The other class will test on Monday. Ms. Gardepe will grade the tests and see which class has a higher average.</td><td><table><tr><td>No fruit or veggie</td><td>Fruit or veggie</td></tr><tr><td>86</td><td>36</td></tr></table></td></tr>
<tr><td>Out of 122 fifth grade students that had pizza for lunch, only 36 of them had a fruit or veggie with their pizza. I thought that most students were not getting a fruit or vegetable with their pizza and I was correct.</td><td>Ryan says to his mom, “I think that if I went to the store and bought 10 bags of this candy, there will be less than three purple candies in every bag”.</td></tr>
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<table>
<tr>
<td>Ms. Gardepe thinks to herself, “I think that if I gave the same test on Friday to a random ten students, and on Monday to the other ten students that the students who take the test on Friday will do better.”</td>
<td>Catherine will watch the 5th grade students go through the lunch line. She will use a recording sheet with two columns. One column will be for students who get pizza and no fruit or vegetable and the other will be for students who get pizza and a fruit or vegetable. She will mark a tally in the correct column as students go through the line.</td>
</tr>
<tr>
<td>
<table>
<tr><th>Friday Test Scores</th><th>Monday Test Scores</th></tr>
<tr><td>76, 85, 92, 96, 86, 76, 98, 100, 89, 92</td><td>78, 82, 57, 83, 78, 99, 65, 77, 66, 89</td></tr>
<tr><td>Average: 89%</td><td>Average: 77%</td></tr>
</table>
</td>
<td>Bag 1: 3 purple candies
Bag 2: 5 purple candies
Bag 3: 4 purple candies
Bag 4: 2 purple candies
Bag 5: 4 purple candies
Bag 6: 5 purple candies
Bag 7: 4 purple candies
Bag 8: 5 purple candies
Bag 9: 4 purple candies
Bag 10: 3 purple candies</td>
</tr>
<tr>
<td>Ryan goes to the store and buys 10 bags of his favorite candy. He will go through each bag and mark down exactly how many purple candies are in each bag.</td>
<td>Of the 20 students who tested, the 10 students who tested on Friday seemed to do better than the students who tested on Monday. The average test score on Friday was 89%, while the average test score on Monday was 77%. I think students might be less likely to study over the weekend which is why the Monday scores are worse.</td>
</tr>
<tr>
<td>Ms.Gardepe is grading test papers. Usually tests are given on Friday in her classroom. This week, the test was moved to Monday because of a snow day. She notices that many of the students who would usually get A’s did not do well. This has happened before when she gave a test on a Monday. She wonders if students do better when they test on Fridays rather than waiting until after the weekend?</td>
<td>Catherine states, “I think that if I watched all of the students in the school go through the lunch line, most of the kids who get pizza will not grab a fruit or vegetable to go with it.”</td>
</tr>
<tr>
<td>Out of 10 bags of candy, most bags had 4-5 purple candies in them. I thought that there would be less than three in each bag, but there were a few more than I predicted. Still, I think there should be more purple in each bag!</td>
<td>Ryan is eating a bag of candy. His favorite is the purple candy. However, he feels like every time he gets this candy, there are never any purple ones! Ryan wonders whether it is just him or if there really are fewer purple candies in these bags?</td>
</tr>
</table>

Student Name: _____ Date: _____

Science Lab Report

Title: _____

Observation/Question:

_____
_____

Hypothesis:

_____
_____

Materials:

_____	_____	_____
_____	_____	_____
_____	_____	_____

Experiment/Procedure:

1. _____
   _____
2. _____
   _____
3. _____
   _____
4. _____
   _____
5. _____
   _____

Data/ Observations:

8 textbooks high	**Distance Traveled** *(Length of tube)*	**Time Traveled** *(Time it took from top to bottom)*	**Speed** *(You will calculate this as a class.)*
Trial #1			
Trial #2			
Trial #3			
Additional Trials			
Additional Trials			

3 textbooks high	**Distance Traveled** *(Length of tube)*	**Time Traveled** *(Time it took from top to bottom)*	**Speed** *(You will calculate this as a class.)*
Trial #1			
Trial #2			
Trial #3			
Additional Trials			
Additional Trials			

Conclusions:

_____
_____
_____
_____
_____
_____

Student Name: _____ Date: _____

Science Lab Report

Title: Marble Lab

Observation/Question:

When given two different angled slopes, down which slope will a marble travel faster?

Hypothesis:

I think that the marble will travel faster down the tube when it is sitting on more textbooks because it is a steeper slope.

Materials:

2 wrapping paper tubes	1 marble	a stopwatch
Yard stick or ruler	duct tape	_____
_____	_____	_____

Experiment/Procedure:

1. Begin by taping the two wrapping paper tubes together to make one long tube.
2. Then, measure the tube and record your measurement in your data table.
3. Stack 8 textbook on top of each other to form a steep slope. Lay the top of the tube on the top textbook and the other end should touch the floor.
4. Roll the marble down the tube and use the stopwatch to time how long it takes the marble to travel from the top of the tube to the floor.
5. Record your data in your data table. Repeat these steps for 3 trials.
6. After you 3 trials, take away 5 textbooks so that there are only 3 textbooks in your stack.
7. Repeat steps 4 & 5 for another 3 trials.

Activity #4—Math Formula Cards

$10\text{-Time} = \text{Speed}$	$\frac{\text{Distance}}{0.025 + \text{Time}}$
$\frac{\text{Distance}}{\text{Time}}$	$0.162 + \frac{0.968 \times \text{Distance}}{\text{Time}}$
$0.0686\ (\text{Time}) + \frac{\text{Distance}}{\text{Time}} - .236$	$\text{Distance} + \text{Time}$
$\text{Distance} \times \text{Time}$	$\frac{\text{Distance}}{\text{Time}} + 15$

Works Cited

"Creating a Genetic Algorithm for Beginners." Creating a Genetic Algorithm for Beginners. Accessed September 19, 2014. http://www.theprojectspot.com/tutorial-post/creating-a-genetic-algorithm-for-beginners/3.
This is a great site to begin your reading on genetic algorithms. It gives a more in depth explanation as to the idea of genetic algorithms and how they are used.

"Darwin's Theory Of Evolution." Darwin's Theory Of Evolution. Accessed November 20, 2014. http://www.darwins-theory-of-evolution.com/.
This resource will provide students and teachers with the background they may need on Darwin's Theory of Evolution in order to apply this knowledge to genetic algorithms.

"Genetic Algorithm Tutorial." Genetic Algorithm Tutorial. Accessed November 5, 2014. http://www.ai-junkie.com/ga/intro/gat1.html.
This was also a great resource for understanding the basic ideas behind genetic algorithms. It is almost like a "dummies guide" to genetic algorithms. Another great read for teachers and higher level students.

"Genetic Algorithms and the Design of Experiments - Springer." Genetic Algorithms and the Design of Experiments - Springer. Accessed September 20, 2014. http://link.springer.com/chapter/10.1007/978-1-4612-1542-4_12.
This site adds to the knowledge of genetic algorithms and the basic understanding of what a GA is. Teachers can read this for a more in depth understanding of genetic algorithms.

"Knapsack Problem." Wikipedia. November 14, 2014. Accessed November 20, 2014. http://en.wikipedia.org/wiki/knapsack_problem.
This site was a great resource for acquiring information about the Knapsack Problem and applying it to genetic algorithms.

"Nutonian, Inc." Eureqa Desktop. Accessed September 15, 2014. http://www.nutonian.com/products/eureqa/.
Eureqa is the software program students will use to derive patterns from their data. This site can be used to download a free trial of Eureqa, as well as obtaining a free software license for educators.

Appendix 1: Implementing Teaching Standards

North Carolina Science Essential Standards

5.P.1.1 Explain how factors such as gravity, friction, and change in mass affect the motion of objects.

5.P.1.2 Infer the motion of objects in terms of how far they travel in a certain amount of time and the direction in which they travel.

Students will explore the above standards through their experiment on speed. Students will discuss different concepts from Force and Motion, including Newton's Laws.

North Carolina Standards for Mathematical Practice

North Carolina Standards for Mathematical Practice #1: Students will make sense of problems and persevere in solving them.

North Carolina Standards for Mathematical Practice #2: Students will reason abstractly and quantitatively.

North Carolina Standards for Mathematical Practice #8: Look for and express regularity in repeated reasoning.

Students will utilize these Standards for Mathematical Practice as they explore just how hard a scientist's job really is. They will attempt to make sense of the data from our lab and discover the formula used to calculate speed. Students will also try to discover patterns in data by using their problem solving skills and then utilizing our robot scientist, Eureqa.