The Science Teachers Bulletin

Promoting Excellence in Science Education

Volume 82, Number 2
Spring 2019

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The Science Teachers Bulletin

Volume 82, Number 2

Spring 2019

Official Publication of the

Science Teachers Association of New York State, Inc.

PO Box 2121

Liverpool, NY 13089

(516) 783-5432

www.stanys.org

A State Chapter of the National Science Teachers Association and a member of the New York State Council of Education Associations

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The Science Teachers Bulletin

Published twice a year

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Don't forget to submit **YOUR** article for the next issue of

The Science Teachers Bulletin

The deadline for the fall issue is <u>July 15, 2019</u>.

See guidelines for submission on the back cover.

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Learning to Argue Like a Scientist When Discussing Social Issues

Uchenna Emenaha

Abstract

As our society becomes more and more complex, social, ethical, and scientific issues also become more nuanced. Responding to complex issues in a democratic way will require students to have well developed understanding of science coupled with strong scientific argumentation skills (Toulmin, 1958, Wells, 1999 & Sadler, 2016). However, adolescents often struggle in creating clear-conscience arguments to articulate their ideas, and research show that as students get older, little growth is seen in this area (Klaczynski & Gordon, 1996). The ability to create a concise argument and validate it with claims is an art form that is not well developed in school-age children; however, research shows that the ability to process and package ideas into meaningful ways and communicate them to others is a crucial step in deepening science understanding (McNeill, K. L., & Krajcik, J. S., 2011). In this article, I present techniques to support teacher's facilitation of student's scientific argumentation development through classroom discourse of social science issues. I provide examples to illustrate how teachers can create a safe learning space where students learn to discuss controversial social issues in scientific ways, using evidence-based reasoning.

Introduction

More teachers should encourage students to argue in class; in fact, I think students should come to class ready to argue every day! However, I am not referring to arguments where fists are raised and students get sent to the principal's office. Instead, I am referring to a specific guided argument called *dialogic inquiry* (Wells, 1999). In this learning model, students gather information about and discuss social issues that have scientific connections (Sadler, 2005). The teacher tries to remain primarily a facilitator, and well-prepared students carry the small group discussions. This means that topics such as gene alteration, protection of endangered species, and space exploration are all fair game. These important issues provide opportunities for students to discuss the interconnections between science and society. This a powerful way to teach students how the knowledge they acquire in class is related to the world around them.

The question that is often on science educators' minds is: "How do you get students to argue about science instead of who has on the coolest shoes?" Simple, you address topics that are of interest to students and related to their everyday lives.

Debatable social science issues provide good topics for supporting students' ability to argue like scientists. Cloning, global warming, and medical research on animals may not make for good dinner conversations due to their controversial nature, but they are great topics to use in class to increase student's awareness of how science can impact society and vice versa.

The social science topics will look different in various subjects. For example, in biology class students can discuss their take on parents who might want to change their future child's DNA in hopes of having the "perfect child." Or perhaps in health they could explore if food subsidies and the government's regulations of food prices contribute to the difficulty some neighborhoods experience in getting access to fresh fruits and vegetables. Additionally, in a computer science class, students can discuss when the lines between freedom of speech and cyber bullying have been crossed.

Preparation

To facilitate the behavior you want from your students, it is important to discuss behavioral expectations ahead of time. You might want to start with, "No shouting matches, please!" and proceed with a quick review of the classroom rules and behavior expectations before you start a lesson using dialogic inquiry. Students should understand the need to respect the views of their fellow classmates, while sharing their viewpoints on the topic at hand. Groupings should include students who share similar and opposing views on the social science issue. A mixed grouping model will give students an opportunity to hear multiple perspectives, which will deepen students' thinking on the facts they use to support or refute the claims they have developed.

In addition, students should have good understanding of the science related to the social issue. Use of academic vocabulary and a conceptual understanding of the scientific learning objectives are essential in order to support student scientific argumentation development. As students work to develop their claim to the social issue, the goal of instruction is not to change students' personal beliefs, but instead to require that they develop strong evidence-based claims to support their positions. A new student entered my class after we had agreed on the rules for discussion, and he said, "My mom got a flu shot but she still got the flu, so flu shots don't work."

Immediately the group took him down for “not talking like a scientist” or stating “evidence to support his claim.”

Students were able to point out the weakness in their classmate’s argument, because they had learned to justify their positions by using the “Claims, Evidence, Reasoning” (CER) model in order to argue like a scientist. CER is a three-step process that guides students to organize their findings and present them in a scientific way (McNeill, K. L. & Krajcik, J. S., 2011). The claim is the student’s argument or position they are taking, followed by the evidence or the measurement or observations they are using to support their argument. Finally, they use a scientific principle to make their final justification or reasoning to support their claim. The student’s peers were able to correct him by saying: flu shots do work (claim), but because the virus can change every year, you have to get a new shot every year (evidence). So, if you get a shot and still get the flu, it doesn’t mean shots don’t work; it might mean that you caught a strain that wasn’t in the shot the doctor gave you (reasoning).

Impressive? Very. By using the CER model to develop arguments, students build the habit of finding evidence to support their statements and become better able to call out nonscientific claims.

Beyond the textbook

Many modern social issues are subject to ongoing changes; therefore, students should rely on authentic forms of data such as credible media sources (Sadler, 2016). The current generation of youth or digital natives are often immersed in their own world of smartphones and social media, which is why utilizing online resources will increase student engagement. Students will find that government, company, and organization websites are good places to gather information. Digital articles are also a good place to find up-to-date information. Of course, students will need to use science content knowledge from class as a basis to support or refute evidence gathered during their research process.

During the process

Once students have acquired the background knowledge and completed their research, the action happens—students are ready to argue. As students engage in small group discussions, they will quickly realize that social science issues often do not have a clear right or wrong answer. Teachers should support students to understand that the key to a successful scientific argument is not to discover the right or wrong answer, but to establish a claim that is supported with evidence and considers all sides of the issue. This will be a huge paradigm shift for students who are accustomed to questions having a single correct response. The argumentation development process is a great opportunity for young scholars to process the reality that social issues can have multiple solutions, as shown in this excerpt from a discussion:

> **Student A:** I believe that GMO's are not good because 80% of farmers all over the world have changed the plant DNA so they don't die when you spray herbicides on them. This has resulted in super weeds and superbugs that cause farmers to have to increase the use of pesticides, which can have a negative effect on our water supply due to runoff. When pesticide enters the water supply, fish can die, and this can reduce the biodiversity of animals in our water.

> **Student B:** GMO's are a great product of modern science and are not bad. Because a lot of people think GMO's are bad, they are the most tested food products in history. Scientists have been able to increase the amount of vitamin A in rice and provided this to developing countries. The increase in vitamin A rice has reduced the number of babies being born blind by half a million in developing countries every year.

Similar to the saying, "You say tomato, I say tomahto," both students are analyzing the same topic, but have two very different viewpoints. As the teacher, it is important to encourage students to consider the views of those that are different from their own. It is also helpful to applaud students' ability to support their claims with evidence-based reasoning and remind them that the classroom is a safe space to share many different perspectives.

Conclusion

Our students often view science and their environment as two separate worlds; therefore, it is beneficial for lessons to intentionally connect the two. A lesson using dialogic inquiry can broaden students' world views beyond the four walls of the classroom. It will create the learning experiences needed for students to make connections between class discussions and real-world events.

Technological advancements of the 21st century make our lives more efficient, but they also bring along a new host of ethical issues and societal concerns. Educators need not shy away from these controversial issues; instead, they should view them as opportunities to create richer science learning experiences. Promoting socio-scientific arguments in class ultimately teaches each student to argue like a scientist.

About the Author

Uchenna Emenaha is a former secondary science teacher and is currently working on her Ph.D. in Curriculum & Instruction in Science Education at the University of Houston. Her research interests include Culturally Relevant Pedagogy, Social Scientific Issues, and Social Justice Education. Uchenna can be reached at ubemenaha@uh.edu.

Analyzing the Mechanics of Women's Roller Derby to Engage Introductory Physics Students

Amanda Dolan & Dan MacIsaac

Abstract

We describe some basic NYSED Regent's level physics examples taken from women's flat track roller derby. Women's roller derby is a relevant, fresh and appealing example for teaching introductory physics which we claim is particularly motivating for young women in which to situate the study of kinematics, circular motion and friction. Using data collected from an author's roller derby personal experiences, we will show how topics from the NYSED Regents physics curriculum can be explored and illustrated. Sample questions for students are appended.

Introduction

Angell, Guttersrud & Henriksen (2004) found that female students consider physics to be one of their most difficult subjects. They also report that physics students find developing a sound understanding of physics concepts to be both essential and difficult. This perceived complexity of physics topics by students is a good reason for physics educators to strive to showcase physics principles in new and interesting situations that can increase engagement for all students. Hatch & Smith (2004) report the use of (traditionally male) sports examples in physics showed positive student responses. Hence, we suggest women's flat-track roller derby as a fast paced, hard hitting, all-women's sport sometimes touted as being one of the fastest growing sports in America.

Since modern flat track roller derby reentered the public sports scene in 2001, there has been little physics literature written on the topic. However, Etkina (1998) reports using rollerblades to introduce basic kinematics to her students and then extending their practical kinesthetic knowledge into the more complicated areas of curvilinear and circular motion, inertia and centripetal force. Student interviews allowed her to record the positive effects that the rollerblading activity had on her students. After Etkina's rollerblading unit, her students claimed to "see physics everywhere."

The New York State Education Department's Regents Physical Setting / Physics Core Curriculum (http://www.nysed.gov/common/nysed/files/programs/curriculum-

instruction/phycoresci.pdf) and the new *New York State Science Learning Standards* (http://www.nysed.gov/curriculum-instruction/2016-adopted-science-learning-standards) require students to collect, represent, tabulate and interpret motion data, perform kinematics calculations determining velocity and acceleration, determine coefficients of friction, analyze interactions between objects, analyze forces via free body diagrams and use Newton's laws to determine motion. This topic is also interdisciplinary in that physical education, physiology (biology) and mathematics are also involved.

Methods Measuring Speeds and Distances

Introductory mechanics physics concepts can be illustrated by questions about women's roller derby behavior like **"How fast do we skate?" "How hard do we turn?"** and **"How fast can we stop?"** Determining typical measurements for derby phenomena forced the authors to conduct many experiments. To make measurements repeatable for students and teachers on a budget, almost all data were collected using stopwatches and the chart of the standard track with path lengths in Figure 1. According to WFTDA (See https://wftda.com/), the circumference of the inside line measures 148.5 ft (45.26m) and the circular crossover path is 178 ft (54.25m). Our stopwatch calculated speeds were verified using an inexpensive toy RADAR gun well known to the physics teaching community – the Hot Wheels Radar Gun taking RADAR data at the end of straightaways, pointing the gun at the skater's chest (See http://service.mattel.com/instruction_sheets/j2358-0920.pdf).

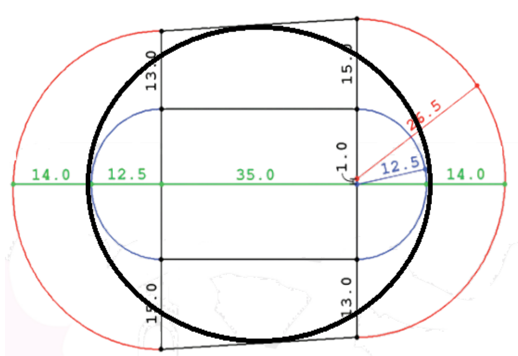


Figure 1. This image shows the dimensions of the Regulation track of the Women's Flat Track Roller Derby Association (wtdfa.com); all dimensions are in feet. The thick black line shows a circular path skated for speed measurements. Retrieved from *https://rules.wftda.com/* with author modifications.

How fast do they go? Determining typical speeds for two most common skating styles: Crossovers vs. Sculling

In roller derby, skaters are always accelerating or decelerating. Skaters generally accelerate by pushing against the floor with their skates, and the track pushes them back in their direction of acceleration. Skaters use a combination of crossovers and sculling to gain and maintain speed. Crossovers are when the skater picks up her outside foot to step over the inside foot to push herself toward the center of the track. Sculling is when the skater keeps all eight wheels on the track and uses a sideways pushing motion to propel herself forward (Figures 2, 3 & 4).

Figure 2. Stance. Toxin Dioxin skates low and centered. (Photo: Robert Krzaczek).

Figure 3. Crossovers. JoJo Thrasher using crossovers. (Photo: Robert Krzaczek).

Figure 4. Sculling. Karmalized sculling around the track. (Photo: Robert Krzaczek)

Using both the stopwatch and the radar gun, we first measured typical speeds of skater TaTa while sculling and crossing over (See Table 1).

	Crossovers	**Sculling**
Δt avg (sec)	10.6 sec	11.3sec

Table 1. Stopwatch Lap Times, same skater but two different paths and techniques. When using crossovers, TaTa naturally followed a circular path throughout (see Fig 3) and when sculling she followed the inside line of the track (see Fig 4).

These data allow us to compare the two styles of skating. At first glance, the similarity in the times for each lap could lead one to believe that there is little difference between the two skating styles. However, TaTa naturally follows two different paths when using these two different skating styles. In the first trial, using constant crossovers, she naturally followed a circular path as she skated on the inside line at the turns and toward the outside line on the straightaways. In the second trial, TaTa was hugging the inside line as she sculled around the track (See Table 2).

	As Calculated from Stopwatch & Figure		**As Measured by Hot Wheels Radar Gun**	
	Crossovers	**Sculling**	**Crossovers**	**Sculling**
Average Speed	5.1 m/s	4 m/s	5.4 m/s	4.4 m/s

Table 2. When following the shorter path and sculling, TaTa's average speed was slower when using crossovers and following a longer path. The radar gun shows a similar comparison (though instantaneously higher due to faster than average velocity during the straightaway) between sculling and crossovers. ***5.4 m/s is about 12 mph.***

How hard do we turn? Finding skaters' centripetal acceleration and the minimum associated frictional force

Knowing speed and turning radius, we can find the centripetal acceleration and the coefficient of friction for skaters. To find the centripetal acceleration and coefficient of friction for a skater using crossovers along a circular path we first draw a Free Body Diagram (FBD) for the skater.

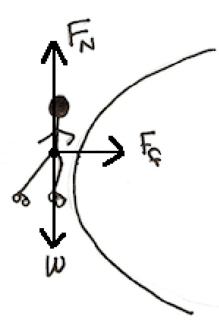


Figure 5. FBD with forces acting on a skater as she skates around the track.

To find the centripetal acceleration we must first find the radius of the circular path the skater was traversing. From Figure 1 we find the radius to be 30 feet or 9.14 meters. The velocity we use here was for the faster crossover skater.

$$a_c = \frac{v^2}{r}$$
$$a_c = \frac{(5.4m/s)^2}{9.14m}$$
$$a_c = 3.2m/s^2$$

3.2 m/s^2 is just under ***1/3g*** acceleration (compare to 0.75*g* – 0.95*g* cornering acceleration for most passenger cars and light trucks). Using the acceleration and the skater's mass, we can find the minimal radial (towards the center) force that friction must supply to provide this smooth centripetal acceleration around the curve.

$$\Sigma F_x = ma_c = F_f$$
$$F_f = ma_c$$
$$F_f = 77.1kg * 3.2m/s^2$$
$$F_f = 247N$$

To find the normal force provided by the surface of the track we also need the skater's weight, also determined from their mass of 77.1kg.

$$\Sigma F_y = ma = 0 = w * F_N$$
$$\therefore w = F_N$$
$$\therefore mg = F_N$$
$$77.1kg * 9.8m/s^2 = F_N$$
$$F_N = 755.58N$$

Finally, we can calculate the minimal (the skater could also be tangentially accelerating as well) coefficient of friction through a constant speed turn using the normal force and the force of friction. Also note that here we are simply providing reasonable figures for sample calculations via the Regent's Physics introductory model of friction; real world friction is quite more complex than the introductory Amontons-Coloumb model (https://en.wikipedia.org/wiki/Friction).

$$F_f = \mu_f F_N$$
$$247N = \mu_f * 755.58N$$
$$\mu_f = 0.33$$

	Skater mass (m)	Normal force (F_N)	Average velocity (v)	Radius (r)	Centripetal acceleration (a_c)	Force of friction (F_f)	Coefficient of friction (μ_f)
Units	kg	N	m/s	m	m/s^2	N	
Crossovers	77.1	755.58	5.4	9.14	***3.2***	***247***	***0.33***
Sculling	77.1	755.58	4.4	9.14	***2.1***	***163***	***0.22***

Table 3. Data and calculations for skater centripetal acceleration and coefficient of friction for crossover and sculling. Passenger vehicle tires typically achieve $0.40 < \mu_f < 0.70$;
Retrieved from *http://hyperphysics.phy-astr.gsu.edu.*

These forces and accelerations are minimum values; we have modeled the path as a smooth circular path at unchanging speed and radius. Adding any nonzero tangential acceleration will increase these accelerations and frictional forces.

Inertia: Falling and the trajectories of skaters leaving circular motion

Falling skaters are standard fare at a derby bout and observing their paths provides a perfect opportunity to see inertia demonstrations. Since a fallen skater has insufficient friction to keep accelerating towards the center of the track, she will tangentially slide to the edge and even off the track. This is because she no longer generates sufficient centripetal force pushing her towards the center of the track to maintain her circular path. Since the direction of angular velocity is tangential to the circular trajectory the skater was traveling on, students can have fun predicting which spectators will get hit by a flying derby girl after she falls and slides into the crowd.

Figure 6. A fallen skater sliding off the track on both knees (the “rock star” fall) (Photo: Robert Krzaczek).

In Figure 6, the skater in red is at the mercy of her own inertia as she slides away from the track; however, the skater in blue, Wolf Blitzkreig, is still on her skates and can shift her center of mass and push hard enough to maintain enough angular acceleration to stay on or hold the track. This is similar to the traditional classroom physics demonstration horizontally whirling a ball tied to a string around a teacher's head and then cutting the string to watch the ball fly off tangentially. In the roller derby example, the ball is akin to the red skater and the force of friction provided by wheels is analogous to the string. Once a skater is no longer up and skating she flies off in the direction of her velocity just prior to her fall. This is a good place to compare the trajectories of the skater's slide after a fall when she falls on the curved portion of the track versus the straight portion of the track.

How fast do we stop? The controlled fall: One knee vs. two knee (rock star) falls

Figure 7. Susan B. Agony, performing a one-knee fall (Photo: Robert Krzaczek).

Figure 8. Scarlett Bloodletter, performing a two-knee "rock star" fall (Photo: Amanda Dolan).

Studying controlled falls and stops in roller derby provide a good example of friction bringing an object in motion to a halt. By recording the stopping time and stopping distance and using basic kinematics, we can compare the acceleration for various falls and intentional stops. Shockin' Audrey demonstrated two controlled falls three times each with recorded stopping distance and time. A stopwatch was used to record the time it took her to slide to a complete stop after she hit the floor. The skate floor was constructed of one by one foot plastic tiles which were counted to find an approximate stopping distance once Shockin' had come to a complete stop.

	Time (seconds)		Distance (meters)	
	One-Knee Fall	Two-Knee Fall	One-Knee Fall	Two-Knee Fall
Average of 3 trials	7.7	2.6	4.2	1.6

Table 4. Observed distance and time for Shockin' Audrey to come to a complete stop while performing a one-knee and a two-knee fall as well as how far that skater slides after making contact with the floor.

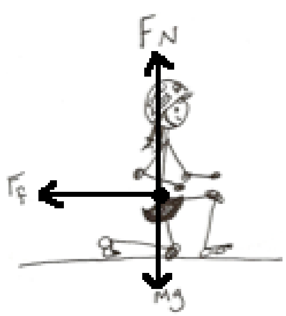


Figure 9. A traditional simplified Free Body Diagram (FBD) for a one-knee fall, re-locating all forces at the CM of the skater.

Experienced physics teachers will note that given the above stopping distance and time data, taken together with final stopped velocities of 0 m/s and the (traditional introductory physics) *approximation* **of constant acceleration, we can already model, formulate and calculate answers to the standard NYSED Regents physics one dimensional kinematics problems.**

Here our simple one-dimensional solution model *further assumes* **that the forces all act on a single point, setting all forces on the skater's center of mass,** *ignoring* **the fact the skater is an extended object whose center of mass is actually offset from the points of contact with the floor, where the normal force and frictional forces are actually applied. This simplified model is traditional and initially taught in this fashion with FBDs; later physics often extends the model offsetting the forces upon extended bodies to examine rotation, stability and tipping - sometimes later during rotational dynamics in Regents Physics, and certainly for more advanced AP or IB physics courses.**

More Stopping Techniques –Controlled Stopping without Falling: The Toe, T-, Plow and Tomahawk stops

Skaters also have (preferred) controlled methods for stopping at their disposal. We recorded and analyzed the stopping times and distance for four of these techniques illustrated in Figures 10-13. Shockin' Audrey and author Farrah Daze Rage collected sample data for these four different kinds of controlled stops, repeated three times each.

	Time (seconds)					Distance (meters)				
	Toe Stop Audrey	T-Stop Audrey	Plow Stop Audrey	Plow Stop Rage	Tomahawk Audrey	Toe Stop Audrey	T-Stop Audrey	Plow Stop Audrey	Plow Stop Rage	Tomahawk Audrey
Average of three repeated measures	3.77	2.48	2.87	1.62	1.16	9.65	5.89	7.62	4.62	2.95

Table 5. Comparing Four Methods of Stopping. Observation data show how long it takes for a skater to come to a complete stop as well as how far that skater slides after initiating the stop.

Figure 10. The Toe Stop. JoJo Thrasher (#800, center) drags her toe-stop, changing speed to dodge an incoming (left) blocker. (Photo: Robert Krzaczek).

Figure 11. T-Stop. Camraderay (#24 on the right), performs a T-stop. (Photo: Robert Krzaczek).

The phrase **"toe stop"** describes both the technique and the braking pad on the front of the roller skates. The basic method of performing a **toe stop** is to extend one skate behind the other, dragging the toe stop (breaking pad) of a skate on the floor (see Figure 10). The harder the skater pushes the toe stop into the ground, the quicker she will slow down. Toe stops (pads) are made from many different materials, and in different shapes. Sin City Skates, a popular site for buying roller derby equipment, sells fourteen different types (shapes and materials) of toe stops. Like a car brake pad, the toe stop material abrades away every time it is used; this wear and tear changes the toe stop shape and contact area and affects stopping ability. Finally, the skater's technique also influences the effectiveness of stopping.

The **T-stop** (see Figure 11) is a common method for stopping in crowded jams (confined spaces) since it allows the skater to keep her legs close together. To execute this stop, the skater must place one of her skates perpendicular to the rolling skate (usually direction of travel). The stopping power from the t-stop comes from the skater pushing the wheels of the perpendicular skate down on the floor (which will also abrade the wheels). The T-stop brings the skater to a stop about one second faster and in almost half the distance compared to using the toe stop. As with the toe stop, there is a materials aspect to the T-stop -- the wear condition and composition

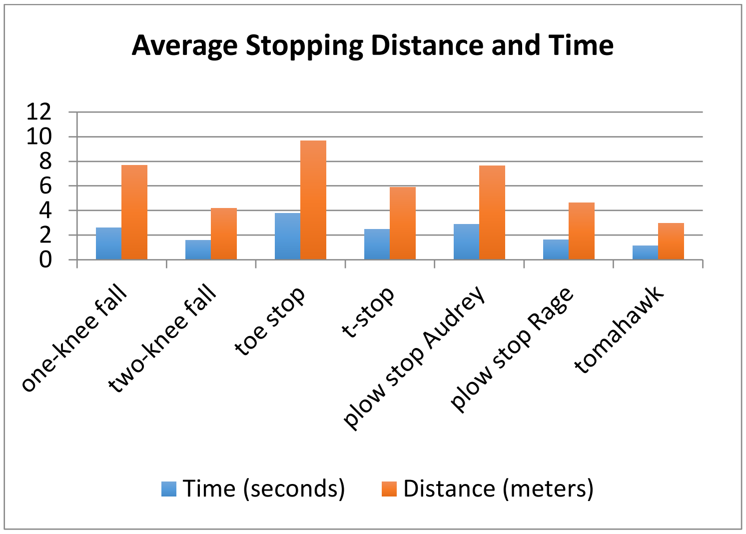
Figure 12. Plow stops. Jacky Spades (#8, far right) and Poplockndropya (#32, center) are plow stopping to slow opposing jammer, GWAR (with gold helmet cover). (Photo: Robert Krzaczek).

Figure 13. A Tomahawk Stop by JoJo Thrasher (#800, on left). Both skaters are moving towards the left. (Photo: Robert Krzaczek).

of the wheels are important. More than forty different types (shapes and materials) of wheels are available for sale.

The **plow stop** is more than just a method of stopping; it is also used for positionally blocking other skaters. To execute a plow stop the skater must skate with a wide, low stance, bending at her knees (similar to a skier's snow plow stance) (see Figure 12). She pushes the innermost wheels of each skate into the floor while turning her toes in. This causes her to slow down quickly and, depending on her stance, can also act as a barrier on the track, impeding skaters who hope to move past her. The low stance also helps with impacts with other players - think risky vehicle driving "brake check" behavior.

The **Tomahawk stop** is one of the fastest controlled stops on skates (and fastest in this paper). In contrast to the plow stop, the tomahawk does not require the skater to spread out on the track, so this stop can be executed in tight packs without fear of tripping other skaters. The tomahawk is also one of the most difficult stops for a skater to learn. To do a tomahawk stop the skater must first transition from skating forward to skating backwards (see Figure 13). The skater will lean forward, in the direction opposite to her direction of motion, with her weight on her toes. Then she lifts up off her heels and rear wheels to stand on both of her toe stops (forming a Tomahawk shape with her body). Without any wheels rolling and only two toe stops dragging under her, the skater skids to a stop very quickly.



Graph 1. Comparing raw data: Average stopping distance and time for all falls and stops described in this paper.

Simple Mechanics of Initial Velocities, Accelerations and Friction Coefficients for Falling and Stopping

We here find the Normal force, initial velocity, average acceleration, force of friction and the coefficient of friction for each falling and stopping method described.

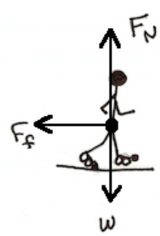


Figure 14. Free Body Diagram of Skater Stopping with a Toe Stop (she drags her toe stop to come to a halt).

For example, let's examine stopping with the toe stop. We have learned that a skater with a mass of 77.1kg comes to a full stop using her toe stop in 9.65m and 3.71s. Starting, we will draw a free body diagram of a skater coming to a halt (Figure 14). To find the skater's weight, we first need the skater's mass, which here is 77.1kg.

$$w = mg$$

$$w = 77.1kg * 9.8\frac{m}{s^2}$$

$$w = 756N$$

We know that the sum of the forces in the y-axis must be zero by applying Newton's second law: because while stopping the skater is not accelerating vertically in the y-direction (see FBD in Figure 14). Hence, the Normal force and weight must vectorially sum to zero due to Newton's second law for the y-direction. Here the skaters' weight and Normal force are equal in magnitude but opposite in direction.

$$F_y = 0 = F_N + (-w)$$

$$F_N = w$$

$$w = 756N$$

Next, we will determine the skaters' initial velocity commencing the stop, then their average acceleration and finally the force of friction necessary to provide that constant acceleration (Note: keep in mind that a skater with a mass of 77.1kg comes to a full stop using her toe stop in 9.65m and 3.71s).

First, we will find the initial velocity. Since the final (stopped) velocity is 0 m/s the initial velocity can be calculated in two steps. We can do that by first calculating the average velocity assuming constant acceleration (common in introductory mechanics) and using the definition of average velocity. Hence, initial velocity is just average velocity doubled:

$$\bar{v} = \frac{v_f + v_i}{2}$$

$$2.6\, m/s = \frac{0 + v_i}{2}$$

$$v_i = 5.2\, m/s$$

Once we have the initial velocity we can find the (again, assumed constant) acceleration (negative means opposite the displacement and initial velocity):

$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t}$$

$$a = \frac{0m/s - 5.2m/s}{3.7s}$$

$$a = -1.4m/s^2$$

Using this acceleration we can find the force of friction that is causing the skater to slow to a stop (here negative means opposite in direction to total displacement and initial velocity):

$$\Sigma F_x = F_f = ma$$
$$F_f = ma$$
$$F_f = 77.1kg\ 8\ (-1.4m/s^2)$$
$$F_f = -106N$$

Finally, we can calculate the (standard Regents simplified Amontons-Coloumb model) coefficient of friction using the normal force and the force of friction:

$$F_f = \mu_f * F_N$$
$$106N = \mu_f * 755.58N$$
$$\mu_f = 0.14$$

For each calculation, we can check by comparison to reasonable figures discussed earlier in this paper, and verify correct units. Repeating the above calculations for an average of three attempts for each stopping time and distance, we can calculate all of the above values for each stopping and falling scenario described:

Kind of Roller Derby falls or stops	Time (sec)	Distance (m)	Mass (kg)	Normal force (N)	Average Velocity (m/s)	Final velocity (m/s)	Initial Velocity (m/s)	Acceleration (m/s^2)	Force of friction (N)	Coefficient of friction
One Knee (avg of 3)	**7.73**	**4.20**	**77.1**	**756**	**0.55**	**0.00**	**1.09**	**-0.143**	**11.0**	**0.015**
Two Knee (avg of 3)	**2.66**	**1.55**	**77.1**	**756**	**0.59**	**0.00**	**1.17**	**-0.442**	**34.1**	**0.045**
Toe Stop (avg of 3)	**3.77**	**9.55**	**77.1**	**756**	**2.54**	**0.00**	**5.07**	**-1.349**	**104.0**	**0.138**
T-Stop (avg of 3)	**2.48**	**5.90**	**77.1**	**756**	**2.39**	**0.00**	**4.77**	**-1.932**	**149.0**	**0.197**
Plow - Audrey (avg of 3)	**2.87**	**7.62**	**77.1**	**756**	**2.65**	**0.00**	**5.30**	**-1.848**	**142.5**	**0.189**
Plow - Rage (avg of 3)	**1.62**	**4.62**	**72.6**	**711**	**2.85**	**0.00**	**5.71**	**-3.549**	**257.7**	**0.362**
Tommie (avg of 3)	**1.16**	**2.94**	**77.1**	**756**	**2.56**	**0.00**	**5.12**	**-4.535**	**349.7**	**0.463**

Table 6: Using average of three measurements of time and distance for each fall and stop, plus skater's mass to calculate the Normal force, average and initial velocity, (assumed) constant acceleration, force of friction and coefficient of friction for each.

Conclusion

We believe that using real-world observed phenomena is a fun way to practice introductory physics, and using physics insight to re-interpret our marvelous world is also fun and empowering. Physical sports are broadly entertaining, and have been shown as appropriate for engaging our students, including some who are generally academically disinterested in physics.

Women's Flat Track Roller Derby provides an authentic, entertaining, and whimsical way to practice (often boring) kinematics, mechanics conceptual reasoning and numeric problem solving. This can be accomplished using approximately valid physical numbers with simplified, approachable Regent's physics models and concepts in a uniquely female-centric and woman-friendly setting that can engage all of our students. Given that Women's Derby is a fast-paced crowd-engaging sport, all physics students can enjoy a little adrenalin and spectacle, reinforce their newly learned physics content by applying it to a new context, and learn about a unique sport and community. Although learning physics is the goal, empowerment and respect are the bonuses. And hopefully all will have a little fun.

About the Authors

Amanda Dolan, born and raised in Rochester, NY, graduated from the State University of NY at Buffalo with a B.A. in Physics in 2003. In 2009 Amanda joined Roc City Roller Derby and donned the pseudonym Farrah Daze Rage. Thinking about physics as she skated came so naturally she decided to focus on roller derby as her 2014 M.S.Ed. PHY690 masters project. Amanda currently runs a daycare out of her home while she works with a colleague to start a new public school in Rochester, NY. She would also like to thank Roc City Roller Derby and all its members for their assistance in this research.

Dan MacIsaac is an Associate Professor at Buffalo State Physics who coordinates the graduate physics teacher preparation programs. He has been inline skating only once while visiting Professor Eugenia Etkina of Rutgers University.

Acknowledgements

The authors gratefully acknowledge the support and contributions of Kelly Pearson in the preparation of this manuscript. She is also a graduate of the University at Buffalo physics program for future teachers and of the M.S.Ed. program in Physics Education from Buffalo State.

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Author Dolan, alias Farrah Daze Rage (sic. Faraday's Cage)
#49, Lead Jammer, doing what she loves (Photo: Robert Krzaczek).

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Appendix A. A Brief Introduction to Roller Derby

Wayne Gretzky said: "Skate to where the puck is headed, not to where it's been." "…Except of course, in our case the 'puck' is the opposing jammer, or a blocker we're trying to control...and it has a mind of its own. Roller derby is so much better than hockey." - Resident Eva (Roc City Roller Derby)

Author Dolan often speaks with people who are unaware of the recent resurgence of roller derby, yet many people remember roller derby's initial incarnation. With banked tracks, high speeds, minimal safety equipment and skaters with strong personae, it is difficult to forget the roller derby created and promoted by Leo Seltzer in the 1930s. Barbee and Cohen's book, *Down and Derby* (2010), delves into roller derby's roots and how the 1970s gas crisis and the increased theatrical nature of the roller derby caused the sport's popularity to wane. Fortunately, in 2001 a group of people in Texas gathered to begin roller derby's meteoric comeback. Joulwan, founder of the Texas Rollergirls, chronicled the resurgence of roller derby in her book, *Roller Girl* (2007.)

These days the most common form of roller derby is played on a flat track and is regulated by the Women's Flat Track Derby Association (WFTDA). Rules for the sport can be found at *http://wftda.com/rules*. Two thirty-minute halves are divided into an indeterminate number of "jams" which can last up to two minutes each. At the start of each jam eight blockers, four from each team, line up together forming "the pack." One jammer from each team starts behind the pack and earns one point for each opposing skater they pass legally and inbounds. Throughout the jam, the blockers are positioning themselves to help their jammer and stop the opposing team's jammer with a variety of hits, blocks and assists. After the jam ends, the skaters leave the track and each team has 30 seconds to get a fresh lineup of skaters out for the next jam.

Brenda "Skater Bater" Delano wrote a short and concise article for *American Fitness* (2010) explaining the basics of roller derby. A first time fan will most likely find roller derby very confusing, but with Delano's breakdown of the sport, any fan can get up-to-speed in just a few minutes. Delano describes the basic rules and game-play of the sport, as well as the intense effort skaters must put forth in training.

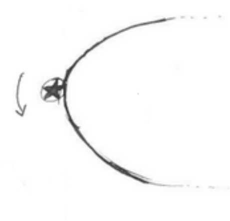
Appendix B. Sample Roller Derby Physics Questions

1. A 65-kilogram roller derby skater skates around the track in a horizontal circle with a radius of 9 meters. The skater maintains a constant speed of 5 meters per second.

A. Calculate the magnitude of the centripetal acceleration of the skater.

Answer: $a_c = 2.8\ m/s^2$

B. On the diagram below, draw an arrow showing the direction of the centripetal force acting on the skater when she is at the position shown.



2. Calculate the time required for a 200-Newton net force to bring a 70-kilogram skater initially traveling at 5 meters per second to a full stop (at constant acceleration).

Answer: t = 1.75s

3. A roller derby skater weighs 750 newtons. The skater races around a cement track, crossing over the whole time. The coefficient of friction is 0.3.

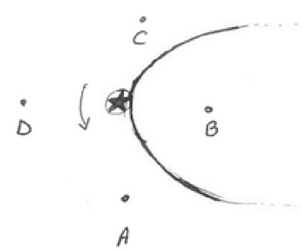
A. Determine the magnitude of the normal force exerted by the cement floor on the skater's wheels as the skater skates across the horizontal surface.

Answer: $F_N = 750N$

B Calculate the magnitude of the force of friction acting on the wheels as the skater skates across the horizontal, cement surface.

Answer: $F_f = 225N$

4. The diagram below shows a skater, represented with a star, skating counter-clockwise at a constant speed around a horizontal track.



At the instant shown, the centripetal force acting on the skater is directed toward which lettered point?

Answer: B

5. A 60-kilogram roller derby skater skates around the track following a circular path during a bout. The radius of her path is 9 meters. She completes 3 laps in 30 seconds.

A. Determine the speed of the skater.

Answer: v = 5.65m/s

B. Calculate the magnitude of the centripetal force on the skater.

Answer: $F_c = 210N$

Saving Hog Island

Carol-Ann Winans

Abstract

A citizen science pilot program titled, “Saving the Western Bays,” was developed to help students investigate and analyze the water quality of the Western Bays in Long Island, New York. The project was the product of a partnership between Adelphi University and Operation SPLASH, a local environmental organization. The following literature review was written to provide a historical background to students who participate in this citizen science project. The review takes a close look at the impacts of natural disasters and human development in the small wetland area known as the Western Bays of Long Island, New York.

Introduction

The Hewlett Bay section of the Western Bays is where I grew up. It's a tiny little wetland ecosystem found in a pocket of marshland on the lower west side of the south shore of Nassau County. Both my parents grew up in Island Park. My grandfather developed a seaplane hangar in the 1940s, after serving as a fighter pilot in World War II. He later transformed the hangar into a marina named, Aero Marine, which is still run and operated by my family. They later added a house to the property in the 1960s.

Having instant access to nature, a rare commodity in a jam-packed Nassau County, I learned to appreciate the natural world. I fished for flounder and bass, trapped crabs by the bucketful, dug for clams, watched ospreys nest, and counted the seals that circulated the marsh when visiting my grandma for Christmas. I also loved water-skiing; my father started us on skis around five years old. We always went out on Monday, my dad's day off. The best Mondays were the days following a heavy rain, creating a calm waterway that resembled a sheet of glass.

Over the years I noticed that the water quality started to decline. We were catching less and less fish, the heavy traffic of boats moved elsewhere, the crabs were gone, the osprey nests were empty, the marshes disappeared little by little, and very rarely did we see a seal. The worst part was if you happened to fall when water-skiing. If the water accidently went in your mouth, you became instantly sick. We blamed it on the exhaustion of the day, but I knew something else had to be going on. I was pretty sure it had to do with a huge concrete block located on the other side of marsh in front of my grandmother's house. What I was going to find out was that concrete block was only one small piece to the puzzle.

While pursuing my Master's degree, I enrolled in an oceanography class at Queens College taught by Professor Nicholas Coch. In class, he mentioned the discovery of artifacts made by his students that were connected to a lost recreational area in the Rockaways known as Hog Island. I was hooked! I began researching the history of hurricanes on Long Island in my spare time. I was fascinated with the idea that an island could just disappear and I was humbled by the power of nature.

After Hurricane Sandy hit, I had to help clean out my grandmother's basement as it was flooded with six feet of water. An 1879 map of Long Island, owned by my grandparents, floated right by me. On the map I saw Hog Island, located right in front of what is now my grandparents' house. My grandmother always told stories about the history of the area. They were never in chronological order, and as a kid, it was hard to tell which stories she actually experienced and which stories were passed on from the people in the area. From my discovery of the map, every time my grandmother told a story, I wrote everything down. I now had the ability to connect the dots.

By this time I was teaching AP environmental science at a local high school and had the blessing of having 21 students who had also become obsessed with trying to improve the water quality in the area that once held Hog Island. Therefore, I reached out to Adelphi University and Operation SPLASH, a local environmental organization, to put together a unique citizen science pilot program to help my students investigate the water quality of the Western Bays. The program, "Saving the Western Bays: A STEAM Problem-Based Learning Citizen Science Project," was the product of that partnership (See Appendix A).

100 Year Storm

"Sandy was not the Big One," he says. "Sandy was a freak, caused by an extremely rare confluence of events." *—Professor Nicholas Coch, Queens College stated when interviewed by Greg Hanscom of Girst.com*

Barrier islands, like Long Beach, NY, are long, narrow, offshore deposits of sand or sediment that run parallel to the coastline. They are separated from the mainland by a bay and scattered marshland. Barrier beaches are separated by tidal inlets. Undeveloped barrier beaches are the first line of defense during storms that threaten coastal communities; they reduce the devastating effects of wind and waves and absorb storm energy (NOAA, 2016).

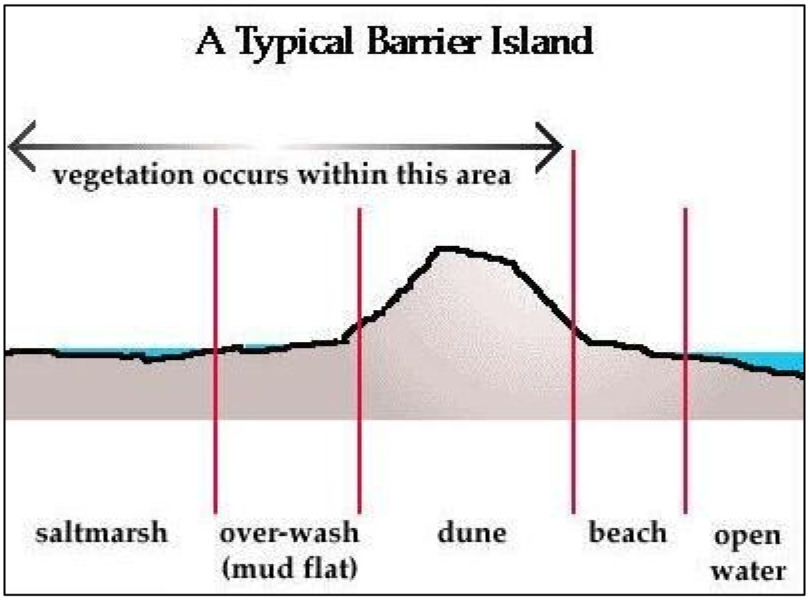


Figure 1. Diagram of an undeveloped barrier beach (NOAA, 2016).

By the time Hurricane Sandy hit the South Shore of Long Island, the reduced wind speed downgraded the intensity to a Superstorm. The storm had started as a low-pressure system over the Caribbean Sea. Two days later, the storm gained hurricane status. Most meteorologists predicted the storm would drift into the North Atlantic and dissipate over colder waters; however, due to a blocking event that some believe to be created by melting Arctic Sea Ice, the storm veered to the west smacking directly into the tri-state area (Hanscom, 2013).

Sandy made landfall at the peak of a full moon tide where a wall of water up to four feet above ground level crashed into Long Beach. As the water entered the developed barrier beach, it churned through streets and turned into rivers that poured into the Western Bays. This enhanced a storm surge to 4.6 feet above ground level by the time it reached the areas of East Rockaway, Island Park, Oceanside, and Freeport (Blake, 2013).

Professor Nicholas K. Coch calls himself a "forensic hurricanologist." Nicknamed "Dr. Doom," Coch has been warning that a major hurricane could take out New York-New Jersey Metropolitan Area (NYNJMA) (Hanscom, 2013). Hurricanes on Long Island are sometimes referred to as "100-year storms," as they are so infrequent that they become a legend rather than a reality. Over the last decade, increased frequency of major hurricanes along the U.S. Gulf and South Atlantic have raised the need for hurricane mitigation plans in these areas. Before Superstorm Sandy, many in the NYNJMA denied the possibility of a storm of that intensity occurring any time soon and ignored all suggestions that these plans were necessary (Coch, 2012). (Note: In 1635, a category 3 Colonial Hurricane wiped out the English settlements in Rhode Island and Massachusetts. Additional devastating hurricanes made landfall on Long Island in 1815, 1821, 1893 and 1938).

Hurricanes moving north along the East Coast have their weaker (left) side against the coast. As the storm hits land, the intensity drops off rapidly. The Long Island coast extends west to east. Unfortunately, for this area, as hurricanes move north, the geographic location of the island guarantees that every hurricane that makes landfall on Long Island carries the destructive (right) side farther inland than standard east coast storms. This is exactly what happened during the devastating 1938 hurricane (Coch, 2012). Reviewing history allows us to acknowledge that Mother Nature can pack a punch stronger than any human impact. With climate change, storms are getting bigger and sea levels are rising. Strategic mitigation is needed in order to live with nature instead of ignoring its increased presence (Coch, 2012). Sandy not only reminded the NYNJMA of the power of nature, it also unveiled hidden environmental issues that may have gone unnoticed.

According to the New York Department of Environmental Conservation (NYDEC), “combined sewer systems” (CSS) are designed to collect storm water runoff, domestic sewage, and industrial wastewater all in the same pipe and bring it to treatment facilities (NYDEC, 2014). During rain events, when storm water enters the sewers, the capacity of the sewer system can be exceeded and the excess water will be discharged directly to a water body. This discharge is called “combined sewer overflow” (CSO). The untreated water may contain untreated sewage that may impact human health. The DEC warns that humans should avoid contact within water bodies containing CSO during or following a rainfall or snowmelt event (NYDEC, 2014).

The Cedar Creek and Bay Park Sewage Treatment Plants in Nassau County have an alternate route for storm water without a CSS; however, during Superstorm Sandy, Long Island faced a large sewage spill from the Bay Park Sewage Treatment Plant (STP). The power for the plant was knocked out for 44 hours by the storm surge preventing water treatment. Roughly, 100 million gallons of untreated sewage overflowed into Long Island's Western Bays in order to prevent further damage to residential areas. Additionally, 2.2 billion gallons of partially treated sewage passed through the plant during the time it was out of service. It took 44 days to restore the plant back maximum capacity (Climate Central, 2016).

Reading Analysis Questions:

- Identify the characteristics of a barrier island.
- Explain how the development/urbanization of a barrier island could influence the impact of a storm-related natural disaster.
- Identify the trade-offs associated with combined sewer systems.
- Construct an argument to defend improvements to infrastructure on Long Island.

Re-Discovering Hog Island

"In the mid-1990s, the Army Corps of Engineers began rebuilding Rockaway Peninsula beaches. They used sands dredged from channels close to shore. Professor Nicholas Coch of Queens College and his undergraduate students were on a routine field trip to study erosion in the Edgemere section of the Rockaways. They stumbled on artifacts—broken plates, beer mugs, bricks, coal, fragments of dolls and, ominously, the wick of a hurricane lamp—embedded in the sand. After some detective work, the professor and his students discovered something that people seldom knew: that an island had existed a century ago off the coast of Edgemere but was destroyed. The discovered artifacts were a window into that lost corner of New York that was destroyed by the fury of an August 1893 hurricane. They rediscovered Hog Island." - *Norimitsu Onishi, New York Times, 2010*

The Island Park community covers one and a half square miles. It has been known as Hog Island, Barnum Island and Jekyll Island. In 1926, Island Park became an incorporated village (Village of Island Park, 2016). After the Revolutionary war, farmers of Hempstead and Oceanside had private clam beds in the area. There were no roads connecting any of the surrounding island; transportation was by boat only (Village of Island Park, 2016).

Hog Island was the easternmost beach of the Rockaways. According to historian Alfred Bellot (1918), in the early 1900s, the area of Hog Island was a large area of scattered marshland vulnerable to environmental change. The weather would carve inlets in one area and deposit sandbars in another. As described, this shifty geology posed a challenge in identifying the exact location of a once-thriving recreational area. It is suggested that a sandbar developed post-Civil War—about a mile wide and shaped in the resemblance of a Hog's back (Onishi, 1997). Developers Willian Wynn, Willian Cafferey, and Benjamin Lockwood created resorts, including bathing facilities and restaurants. One of the resorts, owned by Patrick Craig, was frequented by Tammany Hall politicians. At this time, many members of the political circle referred to the location as the Irish Saratoga (Bellot, 1918).

On the night of August 23, 1893, a great storm now known as the 1893 New York Hurricane made landfall. By the following morning, the Category 2 storm left Hog Island in ruins (Onishi, 1997). After this storm, some redevelopments occurred, but storms continued to carve Hog Island into the fragmented condition described by Bellot.

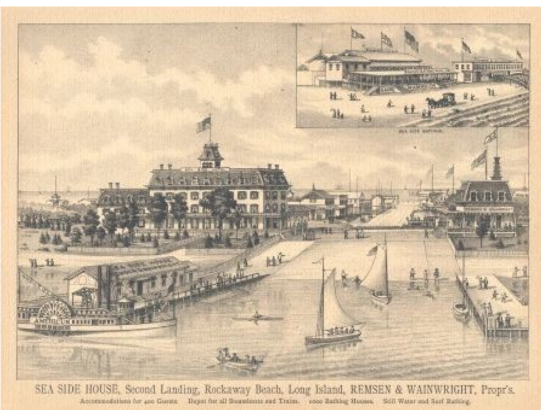
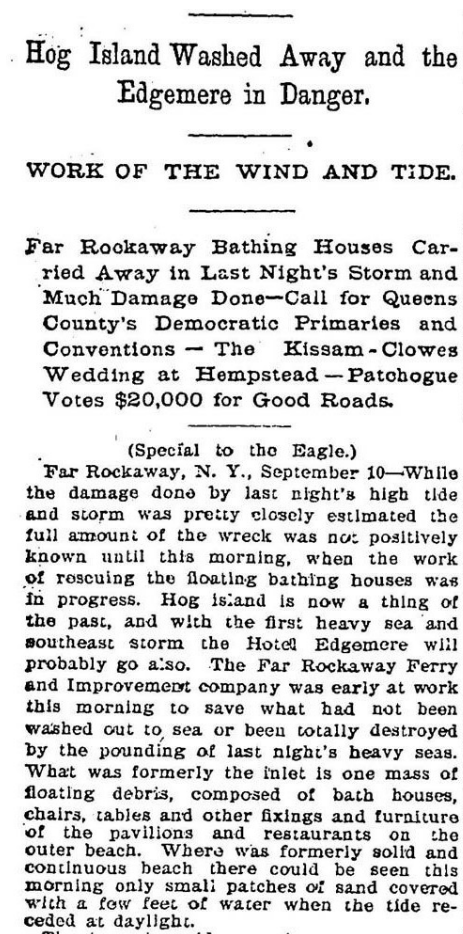


Figure 2. This picture depicts neighboring resort Rockaway Beach. Hog Island probably looked similar (Ephemeral New York, 2009).



Hog Island Washed Away and the Edgemere in Danger.

WORK OF THE WIND AND TIDE.

Far Rockaway Bathing Houses Carried Away in Last Night's Storm and Much Damage Done—Call for Queens County's Democratic Primaries and Conventions — The Kissam-Clowes Wedding at Hempstead — Patchogue Votes $20,000 for Good Roads.

(Special to the Eagle.)

Far Rockaway, N. Y., September 10—While the damage done by last night's high tide and storm was pretty closely estimated the full amount of the wreck was not positively known until this morning, when the work of rescuing the floating bathing houses was in progress. Hog island is now a thing of the past, and with the first heavy sea and southeast storm the Hotel Edgemere will probably go also. The Far Rockaway Ferry and Improvement company was early at work this morning to save what had not been washed out to sea or been totally destroyed by the pounding of last night's heavy seas. What was formerly the inlet is one mass of floating debris, composed of bath houses, chairs, tables and other fixings and furniture of the pavilions and restaurants on the outer beach. Where was formerly solid and continuous beach there could be seen this morning only small patches of sand covered with a few feet of water when the tide receded at daylight.

Figure 3. Article in the Brooklyn Daily Eagle September 10th, 1893.

During the late 1800s, Peter C. Barnum gained ownership of the largest remnants of Hog Island. According to the Historical Review of Island Park 50th Anniversary, a fictional historical story developed identifying the unrelated P. T. Barnum of Barnum and Bailey Circus as a past owner of Hog Island. The story explained that he became interested in this location as a winter home for his circus and bought the island in 1889 before moving his circus to wintering quarters in Bridgeport, Connecticut in 1893 (Village of Island Park, 2016). This story may have developed due to overlapping historical events that occurred just across the channel.

In 1906, William Reynolds, a 39-year-old former real estate developer, expressed interest in developing Long Beach. Reynolds had experience developing in several Brooklyn neighborhoods and developed the world's largest amusement park, Coney Island's Dreamland. In an elaborate publicity stunt, Reynolds had elephants trucked in from Dreamland to help build the Long Beach Boardwalk (Retrieved from *ilovelbli.com*), hence creating a link to both stories. To increase access for large steamboats and sea planes, Reynolds dredged a channel 1,000 feet wide on the north side of the island. The new waterway was named Reynolds Channel (ilovelbli.com, 2016).

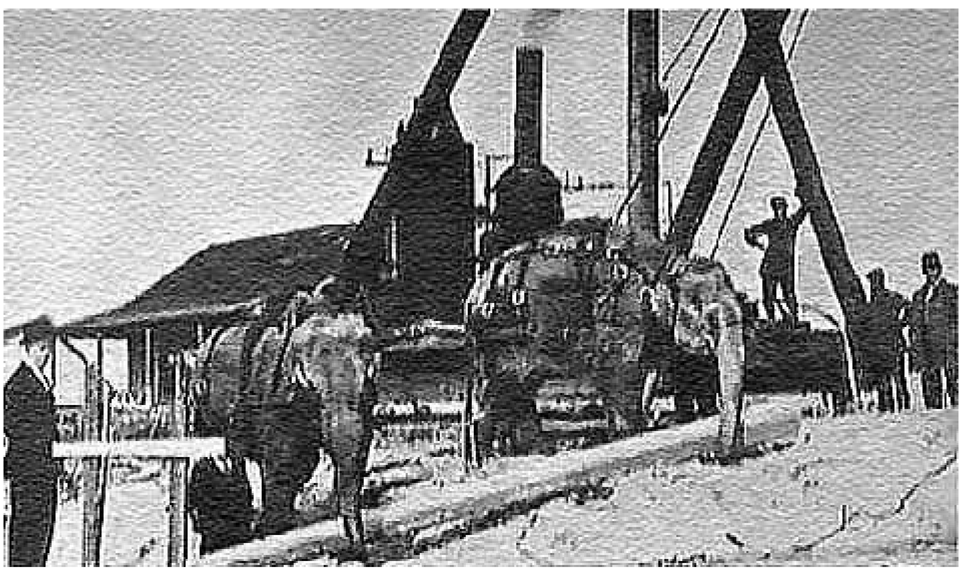


Figure 4. Elephants from Coney Island's Dreamland used to help build the Long Beach Boardwalk, Retrieved from *ilovelbny.com* (Credit: Long Beach Historical Society).

In 1910, Developers Frank Lawson and William Austin planned to develop Barnum Island into the "Venice of the United States." World War I postponed and eventually cancelled this development (Village of Island Park, 2016). In 1921, the land was purchased by the Island Park-Long Beach Corporation and was renamed Island Park and developed into a resort center. The development company Edgeworth Smith and the Island Park-Long Beach Corporation dredged nearby waterways to provide soil to fill in the low-lying marshlands. They pumped in mud five feet deep and allowed the mud to dry. The dredging operation, which took more than a year and was extremely expensive, left the island a sandy desert. The company planted weeds around the island in an effort to prevent the soil from eroding back into the bay (Village of Island Park, 2016).

By 1926, there were fewer than 1,000 property owners. In time, some summer residents decided to become year-round residents establishing the Incorporated Village of Island Park. During Superstorm Sandy in 2012, history repeated itself. Residents of Island Park quickly experienced Hog Island's vulnerability to Mother Nature.

Reading Analysis Questions:

- Identify the geologic characteristics of a wetland ecosystem.
- Explain why Alfred Bellot may have had difficulty identifying the exact location of Hog Island.
- Using the geologic characteristics and human development of land in your argument, justify the Village of Island Park's need for a storm surge mitigation plan.

Bulls Eye of Death

"There is one harbor seal that swims laps around the bay. I know he is swimming in circles because I can predict the time he appears in the channel in front of the house. He must be eating bunker (fish). You should see the bunker. They are everywhere. They practically jump in the boat. The only strange thing is once you take the boat past the Long Beach train trestle, they disappear. Not one bunker in sight." - *Resident of Harbor Isle*

The Bay Park Sewage Treatment Plant (STP) was constructed in the late 1940s to provide secondary treatment using the activated sludge process. The Bay Park STP has a permitted capacity of 70 MGD, but has averaged 59 MGD over the past three years (United Water, 2016). The secondary treatment process starts with a primary screening process. Four mechanically-cleaned bar screens separate solids from solution and three detritus tanks are used for grit removal. Screenings and grit are removed and disposed of at a landfill. At this point, influent flow is pre-chlorinated using sodium hypochlorite as it moves to the primary settling tank. Oils will settle at the top; solids will settle towards the bottom. The two settling layers are added to the sludge digestion process (United Water, 2016) (See Figure 5).

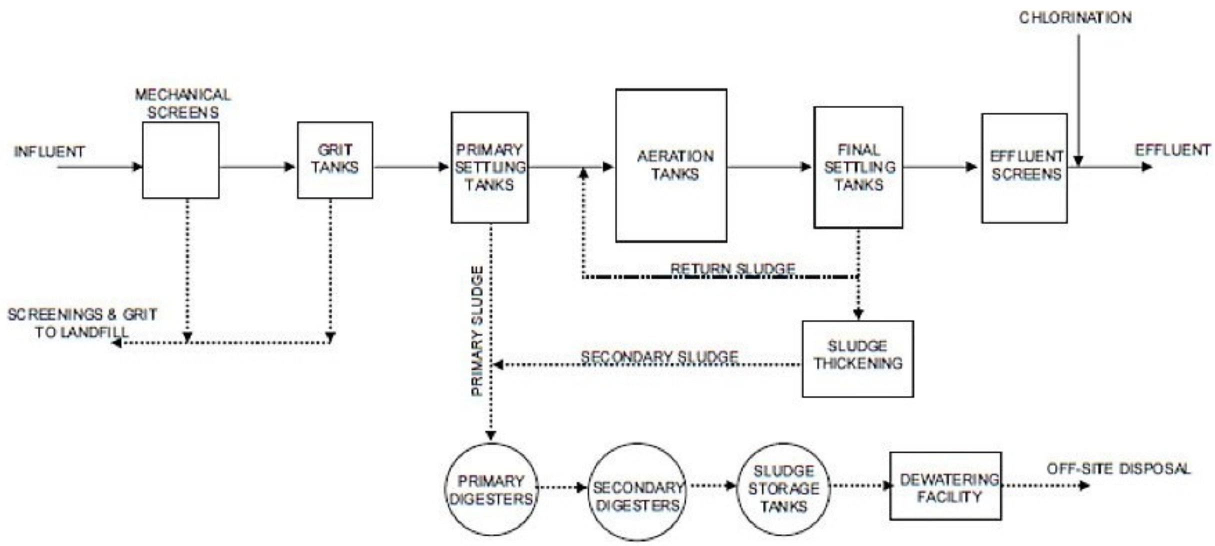


Figure 5. Secondary treatment using the activated sludge process (United Water, 2016).

Remaining influent travels to the secondary treatment process that utilizes five aeration tanks equipped with bubble diffusers. During this process, decomposing bacteria digest remaining organics found in influent wastewater through a process called activated sludge treatment. The remaining treated water then moves to a final settling tank. Sludge generated at the Bay Park STP is processed using four anaerobic primary digesters and two secondary digesters. Methane gas produced by anaerobic sludge digestion is utilized by the Bay Park STP's Power Generation Facility and the Central Heating Facility. Digested sludge is stored in two sludge storage tanks before it is dehydrated using twelve belt filter presses. The dehydrated sludge cakes are trucked to an out-of-state facility for further processing into soil amendments (United Water, 2016).

Wastewater exiting from secondary treatment passes through four final effluent screens to remove any remaining solids. Finally, plant effluent is disinfected using sodium hypochlorite before being discharged into Reynold's Channel through an 84-inch diameter outfall pipeline. This outflow pipe does not have direct access to the ocean (United Water, 2016). It was believed that the effluent that discharges from the plant would be flushed through daily tidal movement out to the Atlantic Ocean, through the Jones Inlet to the East and the Rockaway Inlet to the West. Recent research conducted by Dr. R. Lawrence Swanson at the Stony Brook University School of Marine and Atmospheric Science indicates that they were wrong (CCE, 2016).

Research demonstrates that sewage effluent from Bay Park STP never makes it to the

Ocean. Instead the tides push the effluent north of Reynolds Channel where it accumulates and remains sloshing back and forth throughout the embayment (CCE, 2010) (See Figure 6).

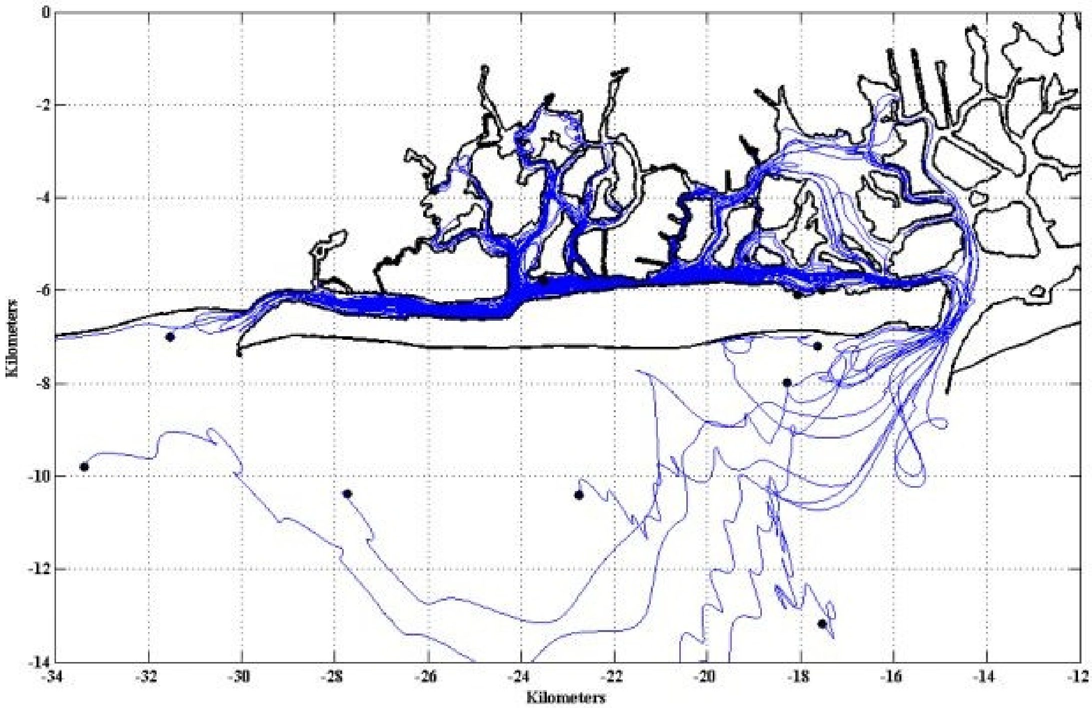


Figure 6. Circulation of effluent of Bay Park STP from outflow pipe (CCE, 2010).

Besides the lack of outflow to the ocean, the Bay Park Plant has an ongoing history of mechanical failures. According to the Citizens Campaign for the Environment (CCE), these failures resulted in numerous sewage overflows.

In March of 2010, local residents documented a brown plume of over 3.5 million gallons of sewage overflowing out of the outflow pump. On August 14, 2011, a storm formed over Long Island that left ten inches of rain in less than two hours. This intense rainfall overwhelmed sewage and pipeline infrastructure causing the release of raw and partially treated sewage into the bays, streets, and homes. Manhole covers were lifted allowing raw sewage to spill onto roads and lawns and into gardens and basements.

On August 28, 2011, Hurricane Irene hit Long Island. The rainfall associated with the storm completely overwhelmed the infrastructure of the plant. The DEC disclosed that during Hurricane Irene, the Bay Park STP exceeded its weekly effluent limitations eight times, with the highest reading being reported as approximately 64,500 pounds per day.

On October 29, 2012, the nine and a half feet of seawater caused by storm surge of Superstorm Sandy compromised the electrical system of the plant, causing the cease of operation for approximately 50 hours. Overburdened collection systems caused overflow into some streets and homes throughout the collection system. The large sewage release created a public health emergency, forcing elective officials to release 60 million gallons of partially treated sewage into Reynolds Channel. To date, over a billion gallons of raw and partially treated sewage have been released into the Western Bays. According to United Water (2016), more than $830 million in federal and state aid was secured to repair the plant's damage. Nassau County has undertaken a project to construct a protective earthen berm and wall around the perimeter of the plant to prevent future damage due to storm surge.

As the 100-year storms turn into every-other-year storms, events that release partially treated sewage into Reynolds Channel become more and more common. Sewage contains high amounts of nitrates, pharmaceuticals, and numerous human and environmental hazards. As nitrate levels increase, eutrophication events become very common (See Figure 7). Algae thrive in high concentrations of nitrates. According to Rob Weltner of operation SPLASH, "In some of the areas surrounding the outflow, pipe divers need to dig through three feet of seaweed (macroalgae) before reaching the bay floor" (See Figure 8).

As the seaweed populations grow, they eventually deplete the nitrates and die. This causes an increase in detritus, resulting in increased decomposition. The process of decomposition requires an enormous amount of oxygen. This increases the Biological Oxygen Demand (BOD) in this area. Dissolved oxygen (DO) is a limiting factor in aquatic ecosystems. If the demand for oxygen is higher than its availability (more BOD with less DO), then the oxygen will be depleted and a dead zone is a created. Fish entering this area do not have enough oxygen to carry out their metabolism and therefore die. Recent research by the CCE has identified the area surrounding the Bay Park STP as the Bulls Eye of Death. Nitrate levels and seaweed populations have resulted in dead zones stretching across the Bay from Island Park to Lawrence

(CCE, 2016).

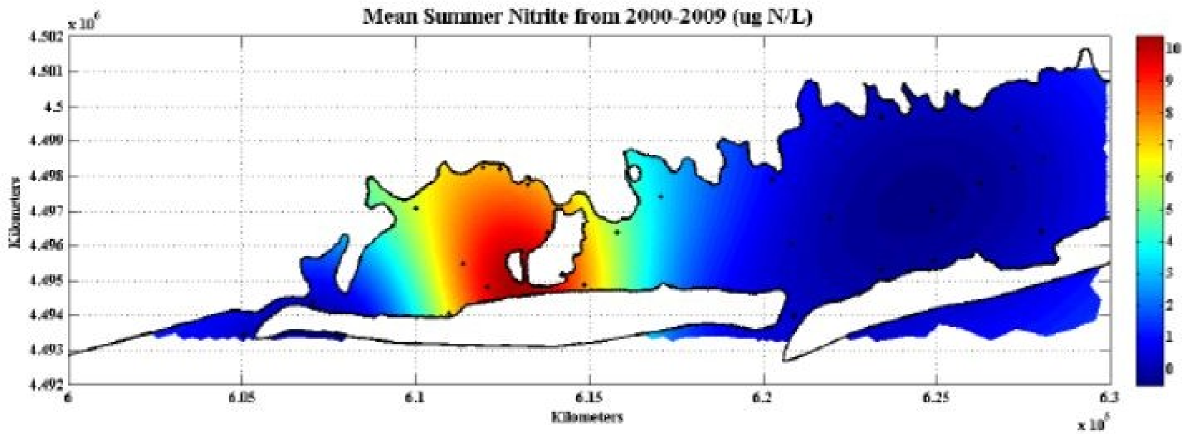


Figure 7. Mean Summer Nitrate levels surrounding Bay Park STP from outflow pipe (CCE, 2010).

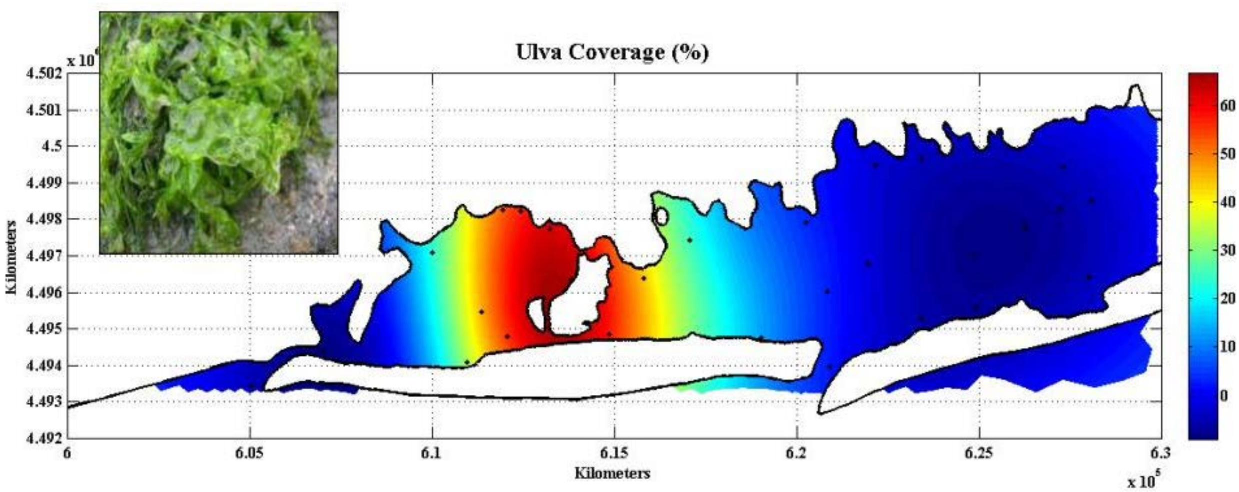


Figure 8. Seaweed coverage surrounding Bay Park STP from outflow pipe (CCE, 2010).

Reading Analysis Questions:

- Identify the components of sewage that are targeted during primary and secondary treatment.
- Describe how each component is removed during the treatment process.
- Explain why sodium hypochlorite is added to sewage effluent before adding it to a waterway.
- Describe a series of ecological changes that might result from sewage discharge into a body of water.

Decades of Decadence

"Many new, handsome houses and stores were erected by settlers who sought the blessing of the health-giving atmosphere in such a location that gave easy access to the city, yet was within a few minutes' walk or ride to the glorious ocean beaches and to the bay." - *Alfred Bellot (1918)*

In the 1800s, the oyster and clam beds flourished in the abundance of eelgrass found in Hewlett and Woodmere Bays. The "Woodmere Oysters" are just one of the many symbols of decadence in this area. During this time, Carleton Macy developed the first steeplechase course in Hewlett Bay Park. The presence of this course encouraged wealthier development for the well-established in this area. The area of Woodmere, which used to be potato farmlands surrounded by marsh, soon grew into an affluent suburban neighborhood. The construction of Broadway and Jamaica Turnpike allowed for easy access to the Valley Stream to Far Rockaway steam railway established by the Railroad Company of Long Island. The surge of new transportation encouraged Samuel Wood to open the Woodsburgh Pavilion Hotel, a lavish hotel designed to offer guests high-life treatment (Bellot, 1918).

By 1909, the Woodsburgh Pavilion Hotel was a resort of the past. Robert L. Burton established legislation that placed the highest known restrictions on suburban residential development. Many houses were constructed with great architectural beauty. Accompanying the lavish houses were the development of tennis courts, golf courses, and club houses. The steam railroad was replaced with an electric service introduced by the Long Island Railroad Company. With these improvements to transportation, residents and those needing an escape from the city frequented the clubs. Thus, the Woodmere Country Club opened in 1910 (Bellot, 1918) (See Figure 9).

Figure 9. The first Woodmere Country Club (Bellot, 1918).

Lawrence was another up and coming exclusive village of the late 1800s. In it, the first developed country club was purchased by the Rockaway Hunt Club in 1884. The Rockaway Hunting Club is the oldest country club in the United States. It originally featured fox hunting and steeplechase racing. When the clubhouse was developed, it overlooked Reynolds Channel

Long Beach (Rockaway Hunting Club, 2016). The Isle of Wright Hotel located near the club attracted writers, artists and playwrights, including Oscar Wilde who frequented it during summertime. In 1895, this hotel was destroyed in a fire (Bellot, 1918).

In 1900, Jacob Wertheim erected a golf course in honor of his fiancé Emma Stern's love of the game. With the help of partners, he rented farmland in Inwood, Long Island, which he then converted into the Inwood Country Club. In less than 10 years, the golf course expanded to 18 holes. Within a few short years, Inwood hosted two major golf championships: the 1921 PGA Championship and the 1923 U.S. Open Championship, scene of Bobby Jones' victory and famous "shot heard 'round the world" (Inwood Country Club, 2016) (Figure 10).

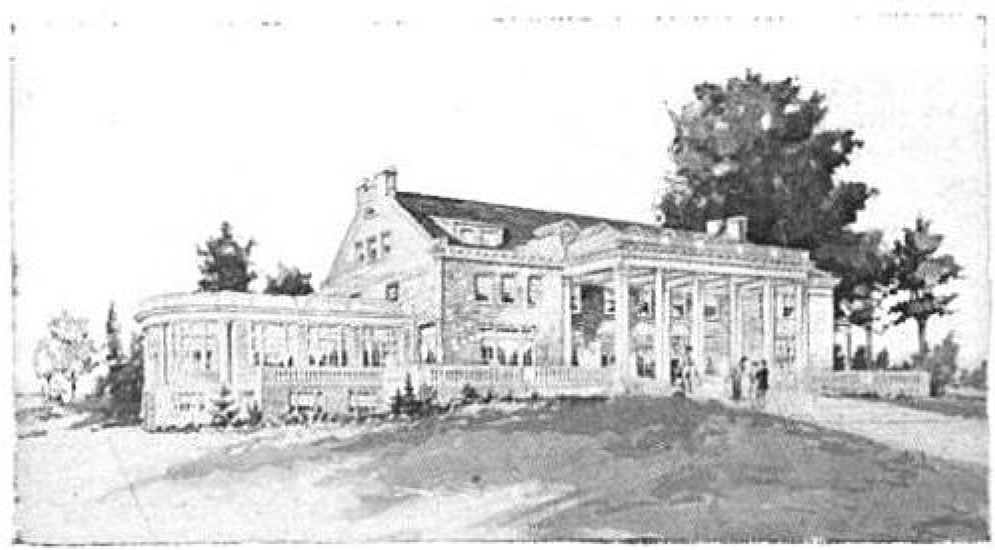


Figure 10. The Inwood Country Club (Bellot, 1918).

Since the early 1900s, many other clubs emerged, including Lawrence and Seawane Country Clubs, and the Bay Park Golf Course. In order to maintain the greens, an abundant amount of fertilizer is applied. The runoff of artificial fertilizer from the numerous golf courses make their way to the Western Bays and add an excess of nitrates to the waterway (Figure 11). This leads to increased algae blooms and decay, decreasing the aesthetics of this once lavish resort area.

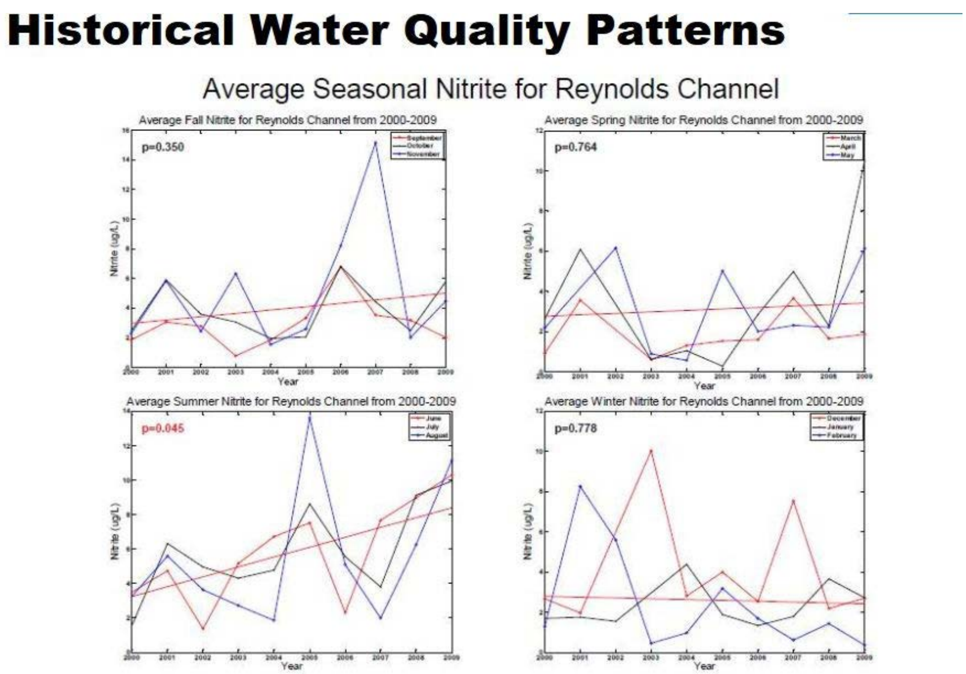


Figure 11. Nitrate levels in Reynolds Channel from 2000-2009 (Battelle, 2010).

Reading Analysis Questions:

- Explain why the "Woodmere Oysters" are a considered to be a luxury of the past.
- Describe how golf course runoff might affect the health and aesthetics of a local waterway.

One with the Bay

"I used to call her spider lady; she never killed any of the spiders in the house because she said they trapped the green flies. In the summer, we would meet them for dinner. Dad would have us swim across the channel to the island, surrounded by marsh, where their house stood. They used rainwater as their fresh water supply. Her husband used to farm fiddler crabs so that they didn't have to venture to shore if he didn't catch fish for dinner that day. She was an amazing cook whether it was flounder, bass, fiddler crab, or eel. She turned it into a meal you would never forget." - *Resident of Harbor Isle*

The morning after Sandy, the winds had subsided and the storm surge receded. The sound of car alarms that had echoed through the night had diminished and people began to emerge from their houses. Those who evacuated returned to find basements and first floors submerged. Boats were found sitting through windows, thrown across golf courses, blocking traffic, and wedged between houses. Halloween decorations that still dangled from branches were now joined by an eerie scattering of storm debris and neighbors' belongings.

When the storm surge slammed through the shorelines of the Western Bays, it showed no mercy. Developed areas, no longer protected by barrier beaches and marshland, illustrated the strength of the storm. Houses curved into “U” formations from the relentless force of water that Sandy swept further and further onto shore. Siding, fences, and docks had been thrown like rag dolls, leaving behind structures still grasping at nails that refused to let go.

Anticipating the worst, Rob Weltner and other members of operation SPLASH took to the waters. Scattered along the Western Bays, they knew of 28 remaining Bay Houses. As stated in a New York Times article (2002), hundreds of Bay Houses dotted the South Shore marshlands during the height of the Western Bays recreational history. According to Long Island Traditions Inc. (2016), there were over 200 Bay Houses in 1965 (See Figure 12). In an effort to conserve slowly degrading wetlands, the Town of Hempstead removed a majority of the houses. Before the storm, most of the remaining Bay Houses could be found off Freeport, Baldwin and Merrick. After the storm, only four remained in the Hewlett Bay area.

Figure 12. Picture of Byrne-Van Wilken Bay House taken by Artist Daniel Pollera (Long Island Traditions, 2016).

Owners consider the Bay Houses a window into the past—a retreat from the hectic fast pace of mainland Nassau county, and an ability to reconnect to a time when a trip to the bay area allowed individuals to appreciate the simplicity of their surroundings. In a New York Times article (2002), Weltner stated, "There are things going on here all the time; different birds come and go. You learn the winds and the tides and the bugs. It’s a whole cycle out here." The Bay Houses remind people that they are a part of nature: they cannot ignore it or control it, but they must acknowledge their role. Weltner and his crew feared the worst. After observing the damage of the mainland, they assumed there was not much hope for the fate of the Bay Houses. Surprisingly, fourteen houses remained. The Bay Houses that survived, although battered by the storm, stood tall above the thick lined marsh of the eastern section of the Western Bays. The houses to the west did not fare as well.

Recent research is indicating that the root systems of the grass species, Spartina alterniflora, is influenced by the influx of excess nutrients in the Bay. Recent improvements to the Cedar Creek and Jones Beach Theater Sewage Treatment pipelines have improved water quality in Zach's Bay by moving sewage effluent to the Atlantic Ocean. This improvement in infrastructure has decreased the presence of excess nutrients in this bay area. Spartina root systems have been forced to grow deeper and deeper into the marshland in order to obtain necessary nutrients. This boost in root growth has reestablished fishery habitats, flood and erosion control, and natural filtration of the water. It is hypothesized that the regrowth of the Spartina root systems may have protected the Bay Houses in this area from the direct impact of Superstorm Sandy.

In the Hewlett Bay area of the Western Bays, a completely different story is developing. The increased presence of sewage effluent and fertilizer runoff provide little reason for the Spartina to establish a root system. The abundance of nitrates in the water, from fertilizer runoff and sewage effluent, allow for direct assimilation of nutrients into the plants from the water. Without the establishment of a root system, these marshes are extremely vulnerable to environmental change, making the surrounding area vulnerable as well—virtually washed away with each storm. With the absence of marshland, the area's natural defense against storm surge and erosion are lost (See Figure 13).

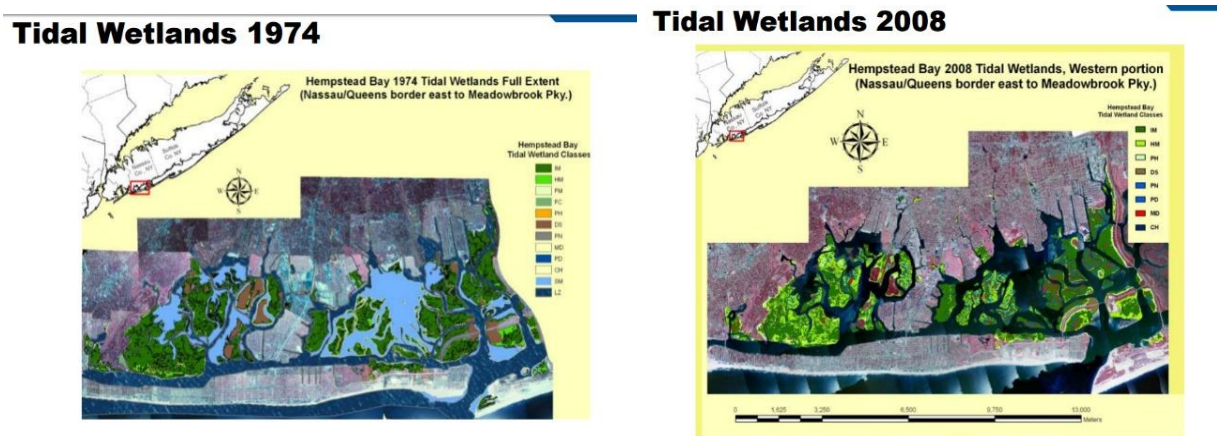


Figure 13. Tidal Wetland development in 1974 and 2008 (CCE, 2013).

Reading Analysis Questions:

- Identify the characteristics and benefits of wetlands.
- Justify the argument that the regrowth of the Spartina root systems may have protected the Bay Houses from the direct impact of Superstorm Sandy.

Was There a Way Out?

"You see right there? Right by the elementary school," she said, as she pointed across the channel towards Long Beach. "There used to be an inlet right there. It was filled in before the house was built. There was a hotel located on the point of the inlet. It was a major tourist spot for sportsmen during the early 1900s. Your father and uncle used to bring home old decoys, reminders of the Hotel, after spending the day out in the bay wandering from island to island."

\- *Resident of Harbor Isle*

Luces Inlet, previously known as Hog Inlet, was located directly in the middle of the Island of Long Beach. Its present-day location would be right at the start of the West End of Long Beach.

Figure 14. 1873 Beers Map of South Hempstead, Long Island, New York.

Jake's Point Hotel was located in Wreak Lead which was once a waterway and town between Long Beach and Island Park. The Long Island Railroad opened a station there from 1888 to 1927 to service the fishing clubs, resorts and hotels in the area. It was a popular destination for sportsman (Harmon, 2014).

Hotel owner Jacob Rathman used to charge $10 for each of his forty rooms. The hotel was open year-round to accommodate the interests of water fowlers and fishermen. Postcard evidence indicates the hotel received guests from 1906 to 1913. Decoys of the Piping Plover bird, now located on the endangered species list, decorate the hotel. These birds once scattered the islands of the Western Bays, and the decoys act as reminders of the history of the area (Harmon, 2014). The Hotel most likely met its final fate at the approximated time of the disappearance of the inlet. Both were probably lost during the Hurricane of 1938 (Figure 15).

Figure 15. Jakes Point Hotel with Jakes Point Hotel Piping Plover Decoy - Wreak Long Island - (Harmon, 2014).

The location of the old Luces Inlet is located directly in front of the outflow pump for the Bay Park STP. Its approximate location is where the ocean met the bay during Superstorm Sandy. The Bay Park STP has been run and operated by Nassau County since its construction in the late 1940s, with operation recently transferred to United Water Long Island. According to United Water, the plant was constructed in the late 1940s to provide secondary treatment for Nassau County Sewage Disposal Districts 1 and 2. The plant was originally designed to treat 27 MGD, but plant capacity expanded to 60 MGD in 1960, and then most recently to 70 MGD. The plant currently serves an overall population of approximately 530,000 residents as well as some commercial entities (United Water, 2016). Research could not indicate if the original plant blueprints anticipated the ability to extend the outflow pipe through Luces inlet. What is known is that once construction began, Luces Inlet was a thing of the past.

Reading Analysis Question:

- Explain how ocean outflow through the historic Luces Inlet may have improved water quality in this area.

Tragedy of Our Commons?

"The population problem has no technical solution; it requires a fundamental extension in morality." - *Garrett Hardin, The Tragedy of the Commons, Science (1968)*

In the article, "The Tragedy of the Commons," Garrett Hardin explains that as the human population increases, individuals will continue to exploit shared resources to the point that the resource becomes unavailable to all. Each person sharing that resource will act in his or her own interest, under the impression that a limitless supply exists. Without education to raise awareness and regulations to conserve natural resources, human nature will have a tendency to deplete its surroundings (Hardin, 1968).

There is hope. The Cedar Creek Water Pollution Control Plant (WPCP) is located in southeastern Nassau County on the Wantagh State Parkway. The plant serves Nassau County's Sewage Disposal District 3, which has a population of approximately 600,000, treating domestic, commercial, and industrial wastewater generated within its service area. Plant effluent is disinfected with sodium hypochlorite prior to being discharged through an outfall extending three miles into the Atlantic Ocean (United Water, 2016).

Recently, the CCE and SPLASH encouraged the state-owned Jones Beach STP to reroute its outfall pipe from discharging into Zach's Bay and hook it into the Cedar Creek Sewage Treatment Plant ocean outfall. This upgrade in infrastructure has lead to the rehabilitation of the eastern half of the Western Bays, allowing clam beds to recover and fisheries to improve (CCE, 2016).

The recent partnership of environmentalists at Operation SPLASH, engineers at United Water, scientists at Stony Brook University, and several government officials of Nassau County, has allowed professionals to raise awareness and improve the condition of the Western Bays. The CCE suggested that the partnership between United Water and Nassau County allow an established, qualified, private contractor specializing in sewage and wastewater disposal to run the sewage treatment plant. This contractor is continuously encouraged to use scientific results and recommendations of the Western Bays Study to make improvements to the Bay Park STP. Some of the improvements in consideration include: 1) the introduction of tertiary treatment that creates effluent with low levels of nitrogen, ammonia, and chlorine; 2) modernization of the plant that will reduce odor and noise; and 3) an additional system to monitor effluent from the outfall pipe and make data available to the public.

At this point, Nassau County is also encouraged to continue a feasibility study for extending the Bay Park outfall pipe into the Atlantic Ocean versus discharge to Reynolds Channel. These improvements will not only increase water quality, but also they will help rehabilitate the surrounding wetlands and local fisheries. It will reestablish a natural barrier to protect the mainland from storm surge. As professor Coch has warned, 100-year storms are legends of the past. We need to acknowledge the force of nature: we may not be able to control natural disasters, but we certainly can control our human impact. It's time to use system thinking to create infrastructure that works with nature to save the Western Bays.

Reading Analysis Question:

- Design an experiment to collect evidence that would support the hypothesis that extension of the Bay Park STP outflow pipe to the ocean will improve water quality in the Western Bays.

About the Author:

Carol-Ann Winans has been a teacher at Lynbrook High School on Long Island for 13 years. During this time she has taught 7th grade Life Science, Chemistry, Living Environment, Biology and Environmental courses. She currently serves as the science chairperson 6-12 for the Lynbrook School district. She has served STANYS as the Nassau Biology SAR for 11 years and served as the Director for the Nassau section of STANYS for 4 years. The author can be reached at nassaudirector@stanys.org.

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Appendix A. Saving the Western Bays: A STEAM Problem-Based Learning Citizen Science Project

Schools are currently making the shift to increase skill sets needed in the 21st century workforce. Students need an in-depth foundation of math and science, and they need to apply this information using lessons that integrate critical thinking, problem solving, creativity and innovation, collaboration, and communication. They need exposure to 21st century careers and local organizations that will inspire students to explore and solve real world problems. To do this, they will need lessons that inspire a blending of creativity in the arts, engineering and innovation, and nurture curiosity and analysis in math and science. They will also need an infusion of the humanities to communicate the needs of the future by understanding our past.

This five-part Citizen Science Program will allow students to use historical review, engineering, and science to evaluate the need for an environmental improvement plan in the Western Bays of Long Island. They will take a systemic approach to analyzing how natural and human impacts can influence an ecosystem. Students will analyze the impacts of natural disasters and human development in wetland areas and establish a plan for mitigation. Use this QR Code to access all of the needed materials.

Using a Pilot Program to Collect Evidence of Student Learning

Kathaleen Burke

Abstract

Transforming classrooms to make the *New York State Science Learning Standards* (NYSSLS) an operational reality has to be a well thought-out process. The Depew, NY School District made the decision to conduct a pilot of a suggested NYSSLS-aligned curriculum and to collect evidence of student learning. The results are useful and worth consideration as a model.

"We wanted to provide a place where kids could practice argumentation."
- Robert Pilon, a teacher at Depew Middle School, summarizing the motivation for their 2018-2019 pilot of SEPUP's Middle School Curriculum

Introduction

During the 2018-2019 school year, the Depew School District in Depew, New York participated in the Western New York (WNY) STEM Quality Partner Program Process. WNY STEM's Quality Partner Program is "a high-level endorsement designed for schools, after-school programs, museums and all formal and informal STEM learning settings to help maximize the impact and value of existing STEM/STEAM programs" (Retrieved from *https://wnystem.org/wny-stem-activities/quality-partner-program/*). The Master Professionals on the team helped the applicant identify strengths and weaknesses and move their program ahead using the "NYS STEM Quality Learning Rubric" (See Appendix A). After the applicant collected evidence that demonstrated that its program met best practice standards, a Certification of Quality endorsement was awarded. In one of the earliest meetings, the Depew Committee members identified the need for a NYSSLS-aligned curriculum that could help teachers bring about changes to foster three-dimensional learning and offer students opportunities to fulfill all middle school level performance expectations. They also wanted to collect data to see if it provided evidence to support their choice.

"Science Education for Public Understanding" (SEPUP) is a research-based science curriculum developed at the Lawrence Hall of Science at UC Berkeley. It uses a design process based on numerous studies and publications that provide evidence around what works best for students. After initial development, the units were field-tested, reviewed for accuracy by scientists, and in some cases, are reviewed by external evaluators to measure student learning. SEPUP's third edition of "Issues and Science" was designed to be aligned with the *Next Generation Science Standards* (NGSS) and the *Common Core Standards* and is strongly correlated with the *New York State Science Learning Standards* (NYSSLS). The program supports teachers with learning pathways that visually show how the three dimensions of the Standards are represented within each "Performance Expectation" (PE) addressed in the program (See *https://sepuplhs.org/pathways2.html*). The Depew middle school teachers specifically focused on SEPUP's "Issues and Life Science" middle school sequence.

Lab-aids, the publisher of SEPUP curricula, offers a pilot program where districts can select a unit to pilot, get professional training on implementation of the unit in the classroom, and implement the unit to decide whether or not to move forward with full implementation. Based on the conversations with all parties, the decision was made to pilot three (3) units, one at each middle school grade level: "Waves," "The Solar System and Beyond," and "Cells to Organisms." Teachers participated in an introductory professional development session on facilitating SEPUP's student-centered, collaborative approach. It was also decided that in an effort to obtain quantitative data the teachers would collect data using a scoring guide relevant to their concerns about student success on "argumentation-based" Performance Expectations (PEs). The scoring guide they selected to use was, "Evidence and Trade-offs Scoring Guide," a signature piece of the SEPUP Program Assessment System (See Appendix B). An additional professional development on assessment helped set protocols for the collection of student work.

Teachers planned to collect data on the "Waves" and "The Solar System and Beyond" units first since the "Cells to Organisms" unit would not be implemented until January. The teachers agreed to meet in mid-December to discuss their findings. At the meeting, data was presented for three tasks at each grade level. Not all tasks were actual SEPUP assessments, but were created by the teachers in an effort to get three data points at each grade level. The general consensus was that the data points did not demonstrate as much about student growth on the Evidence and Trade-offs variable as it did about what the teachers learned by piloting the units. The following are the findings reported by the teachers about the data:

1) The timeframe for data collection was too tight, and therefore, there was not enough time for students to practice argumentation between assessments. A half-year or even two units would have provided more data points based on opportunities to learn.
2) The one area where there was a significant increase in student scores was attributed to the teacher spending more time to set up the task with task criteria and writing frame support.
3) Students are relatively good at pulling out evidence and making a claim, but have trouble articulating the connecting rationale.

The teachers agreed there was value in the action research even though they didn't see the gains they anticipated. They did, however, develop a deeper understanding of student thinking and the next steps they would take. They discussed the implications of the pilot for the next year. Some of them are:

1) The unit could be "wrapped up" in three weeks providing ample time to move on to the next set of Performance Expectations in the next unit to be adopted.
2) The students and the teachers liked the SEPUP format, so they will continue to incorporate note-booking, SEPUP scoring guides, and literacy supports.
3) There are opportunities to collaborate with Language Arts teachers that they will pursue.

Conclusion

The conclusions can be summarized by quoting James Helms, a teacher who piloted both "The Solar System and Beyond" and "Waves" units: "Next year we will know better; we will have more data points and the kids will have had more exposure." The teachers were pleased that they engaged in the documentation and assessment process that supports continuous improvement for both students and teachers. They also look forward to applying their findings in the implementation of additional units in the 2019-2020 school year.

About the Author
Kathaleen Burke has taught middle school science and college level science education courses for fifty years. She has worked with SEPUP as a consultant and is a Lab-aids consultant. She is a Master Professional on the WNY STEM Hub Quality Partnership Team. Kathaleen is a member of the DAL Retirees (dalretirees@stanys.org). The author can be reached at kathaleenburke@gmail.com.

Acknowledgements
Special thanks to James Helms and Robert Pilon, middle school teachers at Depew Middle School in Depew, NY, and Stephanie Brunnett, Science Specialist – Northeast (sbrunnett@lab-aids.com)

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Appendix A. NYS STEM Quality Learning Rubric

The rubric can also be found on the following website: *https://www.stemx.us/resources/new-york-state-stem-quality-learning-rubric-2/* (click on "Download Resource")

NYS STEM Quality Learning Rubric

Prologue

There is broad agreement that STEM education can prepare a qualified workforce necessary to support economic growth. The New York State Board of Regents made significant decisions in January 2015 that recognize the need for STEM education in the Science Strategic Plan process and in establishing alternate diploma pathway options. In addition, the $28 million, seven-year plan to fund P-Tech projects in technology, manufacturing, healthcare and finance is expected to provide thousands of students with coordinated high school and college career preparation in STEM fields aligned with business and employer needs. In addition to support from the Board of Regents, NYS Legislature and Governor Cuomo, the P-Tech projects enjoy support from SUNY and the New York State Business Council, among others.

Even though many PreK through graduate school Science, Technology, Engineering, and Math (STEM) initiatives are being delivered throughout the education continuum across New York State and the United States, much of what has been achieved, thus far, can be found in various unique forms within isolated pockets. When it comes to STEM Education, our State and nation are still in their infancy. STEM education and integrated learning are critical for the development of innovative and effective problem solvers for the 21st Century and beyond. Well coordinated efforts need to be initiated in order to ultimately bring about compelling and powerful STEM learning to every community, school and student.

New York State is in need of a STEM Quality Learning Rubric that is adaptable and flexible for K-12 and higher education levels. The rubric can serve as a holistic guide. It is not intended for assessment purposes but, rather, as a tool for the implementation and transitional building and strengthening of new STEM focused programs. It can also serve to strengthen, with greater clarity, the approach and delivery of existing STEM focused schools and programs. Additionally, this rubric can also support comprehensive schools that desire to incorporate more breadth and depth with STEM related instruction. The essential goal is to achieve a systemic approach to continuous improvement and evolution with integrated STEM delivery throughout K-12 and higher education.

This rubric was developed by a statewide team of STEM leaders from the NYS STEM Collaborative and the Empire State STEM Learning Network. It is being proposed for endorsement by statewide STEM-related organizations and education leaders during the fall of 2015.

NYS STEM Quality Learning Rubric

Not Evident	Emerging	Engaged	Accomplished
#1 Degree of STEM Integration			
No opportunities for students to consider relationships between STEM disciplines,	Students complete tasks that integrate knowledge/skills from two of the STEM disciplines.	Students complete tasks that integrate knowledge/skills from three of the STEM disciplines.	Students complete self-directed tasks that integrate knowledge/skills from all four STEM disciplines and solve an authentic problem.
#2 Connections to Non-STEM Disciplines			
No opportunities for students to make connections between their STEM learning and other disciplines (ie. The arts, Language Arts, Social Studies).	Students are encouraged to make connections between STEM and non-STEM disciplines but are not performing tasks that integrate those disciplines.	Students complete tasks that integrate knowledge/skills from STEM to at least one non-STEM discipline.	Students complete self-directed tasks that integrate knowledge/skills from STEM to multiple non-STEM disciplines including instructional support for quality performance in the non-STEM disciplines. The tasks solve an authentic problem.
#3 Degree of Use of Project-Based Learning (PBL)			
No opportunities for students to be engaged in PBL in STEM disciplines.	Students are engaged in PBL at least monthly in all STEM disciplines.	Students are engaged in PBL at least monthly in all STEM disciplines and at least one non-STEM discipline.	Students regularly complete self-directed, authentic PBL experiences in all STEM disciplines and multiple non-STEM disciplines.
#4 Connections to STEM Careers			
No opportunities for students to explore STEM careers relating to STEM learning experiences.	Students explore careers in some STEM fields but there is no connection with STEM learning experiences.	Students explore one or more STEM careers and are engaged in activities that connect STEM learning experiences to careers.	Students complete tasks in a simulated or real STEM work environment of their choosing and explore multiple STEM careers that directly connect to their STEM learning environment. Tasks include: describing the work/workplace, noting observations in a journal, describing the educational and skill requirements and reflections on the career/career experience.
#5 Individual Accountability in Collaborative Work			
No opportunities for students to work or learn in collaboration with other students.	Students are encouraged to work in teams but the work is informal with no attention to individual accountability.	Students are required to work in formally structured teams with specific methods to measure individual and team accountability.	Students are required to work in formally structured teams with clear evaluation of expectations for team and individual accountability including instruction on interpersonal skills valued in the real-world work setting. Students contribute to the development of accountability rubrics.
#6 Application of the Engineering Design Process			
No opportunities for students to apply the engineering design process.	Students are encouraged to refine higher order cognitive skills but with no direct connection to an engineering design process.	Students are required to demonstrate higher order cognitive skills in at least half of the steps in the engineering design process in suggesting an improvement to an everyday item.	Students are required to demonstrate higher order thinking skills in the engineering design process while using the full complement of design steps, well as iterative thinking. Students demonstrate the process of an everyday technology of their choosing and ideas that could improve the technological device or item.
#7 Assessment of STEM Learning			
Student learning is assessed infrequently and with traditional measures (quizzes, multiple choice tests).	Student learning is assessed periodically with at least one performance-based assessment task.	Student learning is regularly assessed with at least one performance-based task tied to a well-developed rubric.	Student learning is regularly assessed with multiple indicators of success including more than one authentic, performance-based task, presentations and portfolio entries tied to well-developed rubrics requiring students to apply real-world knowledge/skills.
#8 Connections to STEM Partners			
No opportunities for students to benefit from STEM partnerships with other schools, community resources, professional organizations, higher ed or businesses.	Students are engaged in a STEM experience resulting from a STEM partnership.	Students are engaged in multiple STEM experiences resulting from two or more STEM partnerships.	Students regularly complete self-directed, authentic STEM experiences resulting from well-developed partnerships that are purposeful, monitored and evaluated.
#9 Degree of Technology Integration			
No opportunities or resources for students to use technology to support scientific practices and cognitive skills. Technology is used as a demonstration tool in a teacher-centered environment.	Students are provided limited resources to support technology integration and are occasionally required to use technology to support scientific practices and cognitive skills.	Students are provided sufficient resources to support technology integration and are frequently required to use technology to support scientific practices and cognitive skills. Teachers are provided sufficient technology training and support.	Students are provided high quality resources and teachers have access to high quality training to support technology integration. Students regularly use technology to support scientific practices and cognitive skills and apply these transferable skills to solve real world problems in a student-centered environment.

Appendix B. Evidence & Trade-Offs Scoring Guide

EVIDENCE AND TRADE-OFFS (E&T)

When to use this Scoring Guide:

This Scoring Guide is used when students are making a choice or developing an argument about a socio-scientific issue, where arguments may include judgments based on nonscientific factors.

What to look for:

- Response uses relevant evidence, disciplinary core ideas, and crosscutting concepts to compare multiple options in order to make a choice.
- Response takes a position supported by evidence and describes what is given up (traded off) for the chosen option.

Level	Description
Level 4 Complete and correct	The student provides a clear and relevant choice with appropriate evidence and reasoning, including BOTH of the following: • a thorough description of the trade-offs of the decision • reasons why an alternative choice was rejected
Level 3 Almost there	The student provides a clear and relevant choice with appropriate and sufficient evidence and reasoning, BUT one or both of the following are insufficient: • the description of the trade-offs • reasons why an alternate choice was rejected
Level 2 On the way	The student provides a clear and relevant choice BUT evidence and reasoning are incomplete.
Level 1 Getting started	The student provides a clear and relevant choice BUT provides reasons that are subjective, inaccurate, or unscientific.
Level 0	The student's response is missing, illegible, or irrelevant.
x	The student had no opportunity to respond.

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The Science Teachers Bulletin welcomes articles about science and science education. If you wish to submit an article for publication, please prepare the following:

1. Double-spaced manuscript, 12-point font, and one-inch margins (in Microsoft Word format) with figures, tables, photos, or other images separated from the main body of text. Permission for image/photos use may be required.
2. Choose one of the following manuscript types for submission:
    - Feature Article: The main body of your manuscript should be approximately 2,000 words. References, captions, and other supplementary text are not included in the word count. A 200-word abstract should accompany submission of a Feature Article.
    - Innovation in Science Teaching Column: Share your how-to instructional strategies, practical advice, and classroom applicable results of action research. The column should be approximately 750-1000 words.
3. We strongly encourage you to demonstrate how your manuscript aligns with the *NYS Science Learning Standards* (2016) and the vision of *A Framework for K-12 Science Education* (See National Research Council, 2012).
4. References (if used) should appear at the end of the text using APA reference format.
5. An autobiographical sketch including your background, email, telephone number, and address should also be included.

For additional information or if you have any questions, please contact:

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