Using Inquiry to Teach the Common Core State Standards: Two Exemplars

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Using Inquiry to Teach the Common Core State Standards: Two Exemplars
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Abstract

This curriculum project offers two inquiry-based lessons for secondary mathematics teachers. One lesson is a culminating scavenger hunt for systems of linear equations. This lesson incorporates five principles of instruction and four levels of inquiry: confirmation inquiry, structured inquiry, guided inquiry, and open inquiry. The second lesson is an interdisciplinary lesson that involves students modeling bacteria growth with mathematical equations (regressions). This lesson integrates five essential strategies of implementing the Common Core State Standards through inquiry. The author classifies this lesson as a guided inquiry activity. Both lessons are aligned to the Algebra I Common Core State Standards (CCSS), but the concepts in both lessons are standard mathematical skills students will need regardless of the standards.
Introduction

Secondary mathematics teachers often ponder, how they can help students understand why they need to work hard to learn mathematics and they do so while teaching standards adopted by their state, which are often revised and changing. Between 1980 and 2010, New York State (NYS) followed the National Council of Teachers of Mathematics (NCTM) standards, often referred to as the State Standards. In 2010, the Common Core State Standards (CCSS) were adopted by many states, including New York State (NYS). Currently, NYS is seeking to replace the CCSS with the New Generation Standards. The New Generation Standards build on and are modifications of the CCSS, but overall the shift from the CCSS to the New Generation Standards is minimal compared to other shifts in NYS mathematics standards. Throughout the paradigm shift of standards, inquiry has always been an important aspect of the mathematics standards. Therefore, the focus on inquiry to teach mathematics, presented in this thesis, is currently relevant and independent of the current shift in standards. Additionally, this thesis was developed by a NYS secondary mathematics teachers, thus the thesis references NYS Standards, which are currently the CCSS.

More specifically, the purpose of this Curriculum Project is to provide Secondary Mathematics Teachers with two exemplar inquiry lessons for Algebra I. The first lesson will incorporate inquiry through Merrill’s (2002) five principles of instruction that align with problem-centered instruction and the second lesson will incorporate Dana et al. (2013) five essential strategies of implementing the Common Core State Standards through inquiry. Each of the inquiry lessons address multiple Common Core State Standards (CCSS). Additionally, the curriculum provides students with the opportunity to collaborate with peers, take responsibility of their own learning, and make connections between mathematics and real-world problems.
Key Terms and Definitions

CCSSM- Common Core State Standards of Mathematics are the standards adopted by numerous states in the United States, in which this curriculum is aligned (Common Core State Standards Initiative, 2010)

Conceptual understanding- deep understanding of math concepts (EngageNY)

Inquiry- “a dynamic process of being open to wonder and puzzlement” (Banchi & Bell, 2008).

Modeling in mathematics- “the process of choosing and using appropriate mathematics and statistics to analyze empirical situations, to understand them better, and to improve decisions” (Common Core State Standards Initiative, 2010)

NCTM- National Council of Teachers of Mathematics created the standards on which the CCSSM were based upon, the Principle and Standards for School Mathematics

New Generation Standards- New York State Revised Mathematics Learning Standards

Problem-centered instruction- When learners are engaged in solving real-world problems (Merrill, 2002)

QR codes- Quick Response codes- Two-dimensional barcodes that can be scanned using cell phones, chromebooks, or other technology devices

Real-world problems- the ability to apply math concepts to a variety of situations (EngageNY)

Rote memorization- procedural skills (Common Core State Standards Initiative, 2010)

Whole task- an activity that “is representative of those a learner will encounter the world following instruction” (Merrill, 2002)

Worked example- the first problem in a sequence “that shows students the type of whole task that they will learn to complete” (Merrill, 2002)
Literature Review

Paradigm Shift in Mathematics Curriculum

The Mathematics CCSS focused on replacing rote memorization and repetitive procedures with a combination of conceptual understanding and procedural fluency (Common Core State Standards Initiative, 2010). These standards were written as a guide to support teachers as they work to prepare students for mathematics in college, work, and life (Common Core State Standards Initiative, 2010). Even though the CCSS have been revised and replaced in NYS, in 2018, the up-and-coming New Generation Standards have the same underlying tone: real-world problems can promote critical thinking and require students to understand connections between mathematical concepts.

Inquiry in the Modeling Standards

Modeling in mathematics is clearly valued by the CCSS, as well as the revised NYS Learning Standards. Both sets of standards provide a brief description about what modeling in mathematics means and have asterisks placed by the standards that involve modeling (Common Core State Standards Initiative, 2010). However, this offers little support as to how mathematics teachers should incorporate modeling in their classrooms. For example, Quantities is starred in the High School: Number and Quantity category, but there is not an explanation of how the standards in this category incorporate modeling. Also, there is no information on how to implement these standards or integrate modeling of these standards into mathematics curriculum (Common Core State Standards Initiative, 2010).

Four Levels of Inquiry

Banchi, H., & Bell, R. (2008) discovered that not all classroom activities involve the same level of inquiry. To describe the different levels of inquiry that an activity may obtain,
Banchi, H., & Bell, R. (2008) founded a four-level continuum, which also shows teachers that implementation of inquiry can range from low-level inquiry to high-level inquiry. Banchi, H., & Bell, R. (2008) stated that students should progress from each level of inquiry to the next because each level builds on the last and gradually develops students' ability to conduct their own inquiry investigation. The four levels of inquiry are confirmation inquiry, structured inquiry, guided inquiry, and open inquiry (Banchi, H., & Bell, R., 2008).

Confirmation inquiry requires the students to verify a known principle through a procedure given by the teacher (Banchi, H., & Bell, R. 2008). Since the students know the results before the procedure, this level of inquiry is limited and is often used to reinforce students' prior knowledge. This stage of inquiry can also be used to “introduce students to the experience of conducting investigations, or to have students practice a certain inquiry skill” (Banchi, H., & Bell, R. 2008).

In structured inquiry, the students follow a procedure given by the teacher to analyze and critique the results, as well as, to generate an answer to the research question that was given by the teacher (Banchi, H., & Bell, R. 2008). While structured inquiry requires a little more from the students compared to confirmation inquiry, it is still a lower level of inquiry. These first two stages help set a foundation and prepare students for activities that involve higher levels of inquiry.

A higher level of inquiry introduced by Banchi, H., & Bell, R. (2008) is guided inquiry. The teacher provides the students with a research question that the students have to determine how to investigate. Then the students have to draw conclusions based on their investigation. It is important for the teacher to check in with students regarding student procedures (Banchi, H., &
Bell, R. 2008). If students do not have an appropriate procedure to answer the research question, the teacher should use scaffolding to lead them to an investigation plan that makes sense.

The highest level of inquiry, open inquiry, given by Banchi, H., & Bell, R. (2008) is completely student-centered. The students create a research question and an investigation to pursue their research question. This level of inquiry truly allows students to act as mathematicians and scientists because the students are “deriving questions, designing and carrying out investigations, and communicating their results” (Banchi, H., & Bell, R. 2008). Before students can participate in open inquiry, they must demonstrate success in confirmation, structured, and guided inquiry (Banchi, H., & Bell, R. 2008). This means that students must be able to determine how to approach a research problem, carry out the investigation, and draw conclusions from their data prior to proposing their own questions.

Although this article is geared to elementary teachers and students, Banchi, H., & Bell, R. (2008) stated that “most students, regardless of age, need extensive practice to develop their inquiry abilities and understandings to a point where they can conduct their own investigation from start to finish.” Many students, even in middle and high school, still need to progress toward deeper mathematical and scientific thinking. To promote critical thinking and problem solving, teachers can implement Banchi, H., & Bell, R. (2008) four-level continuum of inquiry.

**Merrill’s Five Principles of Instruction**

Merrill’s (2002) five principles of instruction align with problem-centered instruction. His first principle of instruction, “learning is promoted when students are engaged in solving real-world problems” is the central principal (p. 45-46). Merrill (2002) referred to the rest of the principles as stages that branch from this first principle. In order to successfully implement this principle, Merrill (2002) stated that teachers must show students the task they will be able to
solve after the lesson, make sure that the task is an appropriate level of difficulty for the students, and implement a progression of problems that build off one another.

Merrill’s (2002) second principle of instruction, the activation phase, stated that “learning is promoted when relevant previous experience is activated” (p. 46). Teachers should have students recall prior knowledge that can be used as a foundation for the new information. If the students do not have relevant past experiences, the teacher must provide the students with a foundation for new knowledge. The teacher should also encourage students to activate prior ways of organization to help systematize the new information. (Merrill, 2002)

“Learning is promoted when new knowledge is demonstrated to the learner” is Merrill’s (2002) third principle of instruction (p. 52, 43). This is also known as the demonstration phase (Merrill, 2002). While teachers show the students what is to be learned, they should be consistent with their learning goals, provide students with guidance, and implement supportive media (Merrill, 2002).

![Phases for Effective Instruction](image)

*Figure 2. Phases for Effective Instruction. This figure shows Merrill’s five principles of instruction.*

Merrill’s fourth principle of instruction, “learning is promoted when new knowledge is applied by the learner” is known as the application phase (p. 49-50). During this stage, teachers
should provide students with the opportunity to practice skills consistent with the learning goals through a variety of problems (Merrill, 2002). Teachers should also diminish coaching by gradually removing guidance (Merrill, 2002).

The final principle of instruction given by Merrill (2002) stated that learning is promoted when learners are encouraged to integrate the new knowledge of skill into their everyday life (p. 50). This integration will better prepare students to transfer their new knowledge. In this stage, students will present these new skills publicly, reflect on and discuss their new skills, and create innovative ways to implement their new skills (Merrill, 2002).

**Implementation of Inquiry in the CCSS**

Dana, Burns, and Wolkenhauer (2013) worked with teachers and administrators at Woodson Elementary School in Jacksonville, Florida, to study the implementation of the CCSS through inquiry. During this work, Dana et al. (2013) focused on five essential strategies to successfully implement the CCSS through inquiry. The first was that “teachers must be involved in the process” (Dana et al., 2013, p. 79). Since the New York State Mathematics Standards are constantly being revised, teachers’ inquiry can foster one’s knowledge to become familiar with the changes (Dana et al., 2013). Teachers can pose and solve problems regarding the CCSS, as well as, the New Generation Standards, and create “systems of continuous improvement that result in teachers teaching toward clearer and higher expectations and doing this work in more transparent, collegial, and accountable ways” (Dana et al., 2013, p. 80). Additionally, Dana et al. (2013) posed that collaboration is essential in order to effectively implement the CCSS through inquiry; “powerful professional conversations yield powerful inquiry experiences for teachers… powerful inquiry experiences for teachers yield powerful learning experiences for the students they teach” (p. 82). To achieve powerful professional conversations, collaboration needs to occur
among teachers, administrators, and students. Therefore, careful consideration regarding the structure, time, planning, and commitment of collaboration is needed (Dana et al., 2013). For example, professional development opportunities for colleagues to participate in meaningful, grade level and vertical planning should be scheduled regularly (Dana et al., 2013).

Dana et al. (2013) presented “effective Common Core implementation means abandoning a one-standard-at-a-time approach to teaching and looking for new ways to seamlessly integrate multiple standards into a single rich task” (p. 82). “Inquiry can help to actualize that goal” (Dana et al., 2013, p. 82) by inspiring teachers to consider the standards holistically. Inquiry can open teacher's eyes to creating rich tasks, which address several standards and develop students’ higher order thinking, critical thinking, and problem-solving skills (Dana et al., 2013). “Creating a culture of wonder unleashes learning potential and plays a vital role in Common Core implementation through inquiry” (Dana et al., 2013, p. 83). While working with the teachers and administrators at Woodson Elementary School, Dana et al. (2013) concluded that it is essential to teach students how to learn through inquiry by engaging them in activities that develop skills such as critical thinking, problem-solving, and posing productive questions. Since students are used to being passive recipients of knowledge, teaching students to be active learners is a crucial step in implementing Common Core through inquiry (Dana et al., 2013).

The final lesson that Dana et al. (2013) stated as crucial for the implementation of the Common Core State Standards is to have the “right” attitude. Many teachers are intimidated and opposed by the standards that cause change in education, but they are often misinterpreting the standards. “The standards are meant to serve as a guide for teachers to understand the end results they need to achieve to develop students who will be college and career ready” and to “provide an opportunity for teachers to take back the profession of teaching” (Dana et al., 2013, p. 86).
During this paradigm shift in standard changes, teachers need to have an open mind about how to implement inquiry effectively.

**Curriculum**

The two lessons provided focus on incorporating inquiry into Algebra I curriculum and are aligned to the Common Core State Standards. The first lesson is aligned to Merrill’s (2002) five principles of instruction and the second lesson implements the five essential strategies from Dana et al. (2013). Both lessons are independent of one another.

**Lesson One: Systems of Linear Equations Scavenger Hunt**

The main learning objective of this lesson is to solidify student understanding of creating and solving systems of linear equations. This lesson is designed to take two to three 45-minute class periods. Prior to this activity, students should know and be able to solve systems of linear equations using the graphing, substitution, and elimination methods. Students should also be able to model real-world problems with systems of linear equations before participating in this lesson. The author suggests incorporating all four levels of inquiry (confirmation, structured, guided, and open inquiry) into the lessons preceding the scavenger hunt. It is believed this will promote student success in completing the Systems of Linear Equations Scavenger Hunt.

**Five Principles of Instruction in Lesson One: Systems of Linear Equations Scavenger Hunt**

Merril’s (2002) central principal of instruction, “learning is promoted when students are engaged in solving real-world problems” (p. 45-46) and fifth principle of instruction “learning is promoted when learners are encouraged to integrate the new knowledge of skill into their everyday life” (p. 50) are applicable to this lesson. To incorporate these principles, the problems used in the scavenger hunt relate to the students everyday lives and the map is based on the floorplan of the school. Additionally, this lesson also incorporates Merrill’s (2002) second
principle of instruction, “learning is promoted when relevant previous experience is activated” (p. 46). Since this is a culminating activity, the students must recall their knowledge of writing and solving systems of linear equations that they were taught prior to the lesson.

Merrill’s (2002) third principle of instruction “learning is promoted when new knowledge is demonstrated to the learner” (p. 52, 43) does not apply directly to this lesson, but to the lessons preceding this one. Prior to this lesson the teacher is providing the students with new knowledge regarding systems of linear equations that the students will implement in this lesson. This leads to Merrill’s fourth principle of instruction, “learning is promoted when new knowledge is applied by the learner” (p. 49-50). During the scavenger hunt the students will be applying their understanding of systems of linear equations that was learned in previous lessons.

**Level of Inquiry of Lesson One: Systems of Linear Equations Scavenger Hunt**

All four levels of inquiry (confirmation, structured, guided, and open) are incorporated into the questions of this lesson. The confirmation and structured inquiry questions require the students to verify that the system has one solution, determine which procedure (method of solving systems of linear equations) to follow, and generate the solution. In addition, the students must analyze and critique the results. The word problems in this lesson demonstrate guided inquiry. These problems require the students to create a system of linear equations that models the situation. Then the students have to solve their system of linear equations and draw conclusions based on their solution.

The lesson even reaches the highest level of inquiry, open inquiry, given by Banchi, H., & Bell, R. (2008). The problem that involves open inquiry requires the students to work backwards. The students are asked to create a system of linear equations based on a given location. Therefore, the students have to derive questions, design and carry out an investigation,
and check to make sure their investigation will lead them to a correct result. It is important for
the reader to notice this lesson can easily be shifted toward one level of inquiry or another.
Teachers have the flexibility to replace open inquiry questions with confirmation or structured
inquiry questions. If a teacher would like the activity to involve more open inquiry, they could
replace some of the confirmation and structured inquiry questions with questions that require the
students to create their own systems of equations. Students could even be challenged to create
their own word problem that gets them to a certain destination.

**Lesson Plan for Lesson One: Systems of Linear Equations Scavenger Hunt**

<table>
<thead>
<tr>
<th><strong>Learning Objectives:</strong></th>
<th><strong>Lesson Materials:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Students will be able to...</strong></td>
<td>1. Linear Systems of Equations</td>
</tr>
<tr>
<td>1. Solve systems of linear equations using the substitution, elimination, and graphing methods.</td>
<td>Scavenger Hunt Worksheet</td>
</tr>
<tr>
<td>2. Create a system of linear equations given restraints on the possible solution.</td>
<td>2. Map of school imposed on a coordinate grid</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>CC Standards &amp; Modeling Standards:</strong></th>
<th><strong>Key Vocabulary:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Additional clarifications/examples for A.2</td>
<td>2. Linear Equation</td>
</tr>
<tr>
<td>2. CCSS.MATH.CONTENT.HSA.REI.C.5, C.6</td>
<td>3. Coordinate point</td>
</tr>
<tr>
<td>- Additional clarifications/examples</td>
<td>4. Solution</td>
</tr>
<tr>
<td>3. CCSS.MATH.CONTENT.HSA.REI.D.11*</td>
<td>5. Substitution Method</td>
</tr>
<tr>
<td>- Additional clarifications/examples</td>
<td>6. Elimination Method</td>
</tr>
<tr>
<td></td>
<td>7. Graphing Method</td>
</tr>
</tbody>
</table>
*Note: These standards that are starred are modeling standards

**Classroom Activities:**

1. Have students download QR code scanner.
2. Discuss directions for the scavenger hunt with the students.
3. Pair the students together.
4. Start each pair of students with a QR code. Then have the students continue to complete the scavenger hunt.
5. Have a class discussion following the scavenger hunt revolving around these questions:
   a. What did you like about the activity?
   b. What did you not like about the activity? How can we make changes to address what we did not like?
   c. Did you feel as though the activity strengthened your understanding of systems of linear equations? Why or why not?

**Where Students may Struggle**

1. Interpreting and plotting their answers.
2. Selecting the best method to solve the given system of equations
3. Solving any of the systems of equations; especially the word problems, where they have to write the system of equations before they solve the system of equations.
4. Using the QR code scanner.
5. Finding the QR codes that are placed around the school.
6. Showing appropriate work for solving a system of equations.

**How Teachers can be Prepared**
1. Use let statements to assign variables for word problems and remind the students that x comes before y (in the alphabet and in an ordered pair).

2. Provide students with strategies to choose the best method (if both equations are solve for y-use graphing or elimination, if both equations have variables on both sides- use elimination, if one equation has x= or y= use substitution).

3. Have a worksheet for each method that lists to the steps to solve using that method.

4. Download the QR code scanner as a class and do a trial run with their first QR code.

5. Place the QR codes in clearly visible locations on bright paper.

6. Discuss expectations for work when going over the scavenger hunt directions.

### Assessments:

1. The Scavenger Hunt Worksheet will be collected for a grade.

2. The class discussion at the end of the lesson.


### Resources Used:

1. [http://dontpanictheansweris42.blogspot.com/2012/03/systems-of-equations-scavenger-hunt.html](http://dontpanictheansweris42.blogspot.com/2012/03/systems-of-equations-scavenger-hunt.html)

2. [http://www.qr-code-generator.com](http://www.qr-code-generator.com)

### Materials for Lesson One: Systems of Linear Equations Scavenger Hunt

Materials for Lesson One are provided below. First, there is a worksheet for the students to record their work as they complete the scavenger hunt. Next, there is a map of the author’s school imposed on a coordinate grid. The reader will have to create a map of their school. One way to impose a map on a coordinate grid is to draw the axes and school floorplan on graph
paper. Following the map, the author included the scavenger hunt symbols, QR codes, and questions. The reader may have to alter the QR codes and questions depending on the map of their school plan. It may also be to the reader’s interest to use questions that involve their school to help engage their students. QR codes are easy to create. The reader can simply search for a QR code generator online. There are several different QR code generators. The author used http://www.qr-code-generator.com to generate the QR codes provided for this lesson. However, other generators will work and the teacher’s choice will depend on what technology the students will be using to scan the QR code. An answer key for Lesson One is provided in appendix A.
Linear Systems Scavenger Hunt

**Directions:** Each of you will be paired up with a classmate. You and your partner will be given a map of the school and a QR code. Scan the QR code and solve the problem that is provided. Then graph your answer on the map and go to that location. At that location, there will be another QR code that you need to scan in order to receive the next problem to solve. Each QR code has a symbol next to it. When you first get to a QR code, draw the symbol in the space on the left. Then do all of your work to solve the problem in the space on the right. Circle your final answer. When you end up at the same QR code that you started with, come talk to me.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Work for each problem</th>
</tr>
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<td></td>
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</tbody>
</table>
Symbols, QR codes, & Questions

Solve the system of equations using the method of your choice.

11x + 8y = -80
x - 16y = -208
The Junior class is selling Bloomfield apparel for a fundraiser. Mrs. Geary ordered two long-sleeve shirts and four t-shirts for $78. Mrs. Romanola ordered two long-sleeve shirts and two t-shirts for $54. How much does a long-sleeve shirt cost? How much does a short-sleeve shirt cost?
Solve the system of equations using the method of your choice:

\[
\begin{align*}
y &= -9 + \frac{9}{13}x \\
y &= -\frac{23}{2} + \frac{1}{2}x
\end{align*}
\]
The Algebra I class is trying to raise money for a supercomputer to do their math for them so they don’t have to do homework anymore. They decide that the best way to make money is to work for other students for an hourly wage- a cheaper wage to help a student with their homework, and a more expensive wage to carry a student’s materials (books, pencils, etc.) to their classes. Let y be the hourly wage to help another student with their homework and let x be the hourly wage to carry another student’s materials (books, pencils, etc.) to their classes.

For 5 hours of helping Dakota with his homework and 3 hours of carrying Dakota’s materials to class, Hannah earned $87.

For 15 hours of helping Dayna with her homework and 18 hours of carrying Dayna’s materials to class, Gretchen earned $387.

What’s the hourly wage for the two jobs?
Using the method of your choice, solve the system of equations:

\[ 3x - 2y = 26 \]
\[ 16x - y = -16 \]
Ian and Kaedan decide to raise Yaks and Pigs to earn money for college. They sell Yaks for $425 and Pigs for $127. After a lot of work, they have 5 times as many Pigs as Yaks to sell. Unfortunately, one of the pigs got sick and died. They go ahead and sell what they have. They earn $1,993. How many Pigs, $x$, and how many Yaks, $y$, did Ian and Kaedan sell?
Solve the system of equations using the method of your choice.

\[ y + x = 2 \]
\[ 4y + 57 = x \]
Create a system of equations that would take you to Foyer 1. Make sure your system works. Plot your solution on your map and go to Foyer 1.
Solve the system of equations using the method of your choice.

\[
\begin{align*}
3x - 5y &= 17 \\
y &= -7
\end{align*}
\]
Solve the system of equations using the method of your choice.

\[
y = 2 - \frac{1}{5}x \\
y = -6 - \frac{11}{15}x
\]
Lesson One Summary

It is the author’s intent to provide Lesson One as an innovative lesson that incorporates technology and engages students. Unlike typical mathematics lessons, this scavenger hunt requires students to move around the school. The author would also like the reader to note that the general format, a QR code scavenger hunt, can be used for any mathematics topic. Teachers are encouraged to modify the Lesson One materials to meet their students’ needs.

On the contrary, Lesson Two takes a different approach to incorporate inquiry through real-world problems. In this cross-curricular lesson, the students conduct an experiment by collecting bacteria samples from several surfaces in the school. After collecting bacteria samples, the students record and analyze data to draw mathematical conclusions about bacteria growth.

Lesson Two: Bacteria Experiment

The learning objectives of Lesson Two, the Bacteria Experiment, are to teach the students about how to model real-world problems using mathematical equations and how to determine which model is the best fit of specific real-world problems. The warm-up and experiment for Lesson Two should take one 45-minute class period. It is important for the teacher to have petri dishes set up with agar prior to the experiment. This will save class time. For the experiment, students will choose three surfaces to collect bacteria samples from. They will contaminate the agar in the petri dishes with their bacteria samples. After the experiment, the students will count the number of bacteria colonies in their petri dishes every day for approximately two weeks (not including the days over the weekends).

While waiting for the bacteria to grow, within those two weeks, the teacher should introduce a unit on modeling real-world problems. The students should be taught how to find
linear, exponential, and other types of regression models using their graphing calculators. In addition, how to answer questions using those regression models.

For students to be successful in the unit on modeling real-world problems and in the Bacteria Experiment lesson, they will need to be familiar with tables, graphs, equations, and real-world problems of functions. The students will need to be able to write equations that represent tables and graphs of linear, exponential, and quadratic functions, as well as, identify the pattern of change in tables and graphs of these types of functions. Additionally, the students will need to be able to create graphs of functions, given a table of values.

After the unit on modeling real-world problems, the students should have their tables complete (number one of the Reflection Questions) for the Bacteria Experiment. The students will then answer the rest of the Reflection Questions with their partner. This should take approximately two 45-minute class periods.

**Five Essential Strategies in Lesson Two: Bacteria Experiment**

Dana et al. (2013) stated that “creating a culture of collaboration unleashes learning potential”. Since this is a cross-curricular lesson, the math teacher should use this opportunity to collaborate with the science department. This lesson also provides students with the opportunity to collaborate with their peers, as they will be working in pairs or small groups. The standards covered in this lesson are provided in the lesson plan below. Multiple standards that “interrelate and speak to one another to create opportunity for students to develop higher-level and critical-thinking skills necessary to be college or career ready in the twenty-first century” (Dana et al., 2013) are addressed in this lesson.

The warm up to this lesson hooks student interest because the questions are open-ended, relate to real life, and allow the students to make hypotheses regarding the activity. Students will
also feel comfortable answering the warm up questions because they cannot answer the questions incorrectly. A culture of wonder is created because the students are active learners by collecting and analyzing data to test their hypotheses.

The first (teachers must be involved in the learning process) and last (teachers must have the “right” attitude) strategies given by Dana et al. (2013) emphasize the teacher’s role in the classroom. Teachers must be willing to use inquiry to implement the CCSS and must have a positive attitude. This lesson requires the teacher to take a risk. In order for the lesson to be successful, the teacher must let the students take control of their own learning. This lesson holds students to high expectations because they are the ones that are collecting and analyzing the data. The teacher is there to guide the students when needed, but the goal of the lesson is for students to work together and to be held accountable for their own learning. This creates two roles; the teacher as the facilitator and the student as the active learner.

**Level of Inquiry for Lesson Two: Bacteria Experiment**

This lesson could be categorized as Banchi, H., & Bell, R. (2008) second (structured) or third (guided) level of inquiry. The lesson is composed of research questions prepared by the teacher. It is the student's responsibility to determine the results, which is why the lesson surpasses the first level of inquiry, confirmation. Directions are provided for students to collection and recording of data, which is why the lesson could be classified as structured inquiry. However, the reflection questions require the students to investigate and draw conclusions based on their investigation. Therefore, the lesson could also be classified as guided inquiry. This lesson could even be brought to open inquiry (level four) if the teacher implementing the lesson collaborated more with the science teacher on how the students could
design the experiment themselves. Thus, making the lesson more student-centered rather than teacher-directed.

**Lesson Plan for Lesson Two: Bacteria Experiment**

<table>
<thead>
<tr>
<th>Learning Objectives:</th>
<th>Lesson Materials:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Students will be able to…</strong></td>
<td></td>
</tr>
<tr>
<td>1. Model real-world problems using mathematical equations.</td>
<td>1. Cotton swabs</td>
</tr>
<tr>
<td>2. Determine which model is the best fit of specific real-world problems.</td>
<td>2. Petri dishes</td>
</tr>
<tr>
<td></td>
<td>3. Agar</td>
</tr>
<tr>
<td></td>
<td>4. Disposable gloves</td>
</tr>
<tr>
<td></td>
<td>5. Tape</td>
</tr>
<tr>
<td></td>
<td>6. Sharpies/markers</td>
</tr>
<tr>
<td></td>
<td>7. Incubator</td>
</tr>
<tr>
<td></td>
<td>8. 70% EtOH (ethanol)</td>
</tr>
<tr>
<td></td>
<td>9. E.coli</td>
</tr>
</tbody>
</table>

**CC Standards & Modeling Standards/ NYS Algebra I Mathematics Learning Standards (Revised 2017)**

1. CCSS.MATH.CONTENT.HSN.Q.A.1-Q.A.3*
2. CCSS.MATH.CONTENT.HSA.CED.A.2, A.3* - Additional clarifications/examples
3. CCSS.MATH.CONTENT.HSF.BF.A.1*
4. CCSS.MATH.CONTENT.HSF.LE.A.1, A.2* - Additional clarifications/examples for A.2
5. CCSS.MATH.CONTENT.HSF.LE.B.5* - Additional clarifications/examples

**Key Vocabulary:**

1. Independent variable
2. Dependent variable
3. Pattern of change
4. Function
5. Regression model
6. Exponential function
7. Linear function
8. Quadratic function
9. Mathematical modeling
### Classroom Activities:

1. Warm-up (Think-Pair-Share)
2. Give students clear directions for the Bacteria Experiment.
3. Have students carry out the Bacteria Experiment.
4. After two weeks of recording data and learning about modeling real-world problems, have the students complete the Reflection Questions for the Bacteria Experiment.
5. Have the students find a different partner. Then have each pair of students write down three sentences regarding three common takeaways from the experiment that specifically relates to the mathematics behind it.

### Where Students may Struggle:

1. Carrying out the experiment accurately.
2. Counting the number of bacteria colonies correctly.
3. Interpreting what the data values (in the table) represent.
4. Graphing the data values from the table.
5. Determining which type of function best fits the data values of \((time, number\ of\ colonies)\).
6. Using the calculator to find the regression model that best fits the data values of \((time, number\ of\ colonies)\).
7. Using the regression model to answer questions involving the real-world problem \((time, number\ of\ colonies)\).

### How Teachers can be Prepared

1. Clearly go over the direction before letting the students start the experiment. Also discuss that
human error occurs in both science and math, so do not get discouraged if the experiment does not go as planned.

2. Show images of colonies and do a practice count as a class together before letting students count the bacteria colonies on their own. Also, as a class, they can determine how to count colonies, what counts (or doesn't count) as a colony, etc.

3. As a class, discuss what does x and y mean in the context of the experiment.

4. As a class, discuss what does x and y mean in the context of the experiment. Discuss which axis is x and which is y. Also, discuss how the first column of the table contains the x values for each of the columns to the right, which are y values. So, they will have to use each x value three times (once for each surface).

5. Have a worksheet that the students can refer to if they cannot remember which regression fits with which pattern of change (straight line- linear, curved line (as x increases, y increases at an increasing rate)- exponential, etc.)

6. Have a worksheet with the calculator steps for finding regressions (STAT, Edit, type data into L1 and L2, STAT, Calc, Reg.)

7. Provide two worked out examples using the regression equations (one where you have to substitute x and one where you have to substitute y)

Assessments:

1. The students papers for the lesson with be collected and assessed.

2. The sentences for the closing activity will also be collected.
Materials for Lesson Two: Bacteria Experiment

Materials for Lesson Two are provided below. There is a warm-up worksheet that should be given to every student. The author suggests organizing the warm-up as a think-pair-share exercise. Have the students think individually about the answers, then have the students share their thoughts with a partner, and finally, discuss the warm-up questions as a class. Next, there is worksheet with the directions for the experiment. The author suggests discussing the directions as a class before unleashing the students on the experiment. Additionally, the author provided a packet with reflection questions regarding the experiment. This is where the students will record their data (the number of bacteria colonies counted each day). The questions in this packet help students draw conclusions and make mathematical connections regarding the experiment. An answer key for Lesson Two is provided in appendix B. Since this lesson involves an experiment, there will be differences in the data collected. Therefore, the author would like to note that the answer key is specific to the experiment she carried out and should only be used as a model for the reader.
WARM-UP: Individually, answer the following questions in the space provided. When you have finished each question, share your responses with your partner.

1. List a few surfaces that you think have a lot of bacteria on them.

2. List a few surfaces that you think do not have a lot of bacteria on them.

3. What do you think will happen to the number of bacteria colonies if we get samples from these surfaces and let them sit in petri dishes for a few weeks?
Bacteria Experiment Directions

1. Make sure you and your partner have all of the necessary materials:
   - 3 petri dishes with Agar
   - 3 cotton swabs
   - 1 sharpie(marker)
   - Tape
   - 2 pairs of disposable gloves

2. State the three surfaces you and your partner will be testing:
   a. ______________________________
   b. ______________________________
   c. ______________________________

3. State which surface you think will have the most bacteria on it: ________________________

4. Put a pair of disposable gloves on, grab a cotton swab, and swab one surface. Then, gently
   wipe the swab onto the agar in a zigzag pattern. Place the cover on the petri dish and tape it shut.
   Make sure to label the dish with the surface name, today’s date, and your names.

5. Repeat step 4 for the other two surfaces.

6. See me when you are finished with step 5 for further directions.
Reflection Questions for Bacteria Experiment

1. Record the number of bacteria colonies from your petri dishes in the following chart.

<table>
<thead>
<tr>
<th>Time (in Days)</th>
<th>Number of Colonies</th>
<th>Number of Colonies</th>
<th>Number of Colonies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surface 1:</td>
<td>Surface 2:</td>
<td>Surface 3:</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>------ Saturday ------</td>
<td>------ No record ------</td>
<td>------ No record ------</td>
</tr>
<tr>
<td>6</td>
<td>------ Sunday ------</td>
<td>------ No record ------</td>
<td>------ No record ------</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. Which surface started with the most bacteria? How did you determine this?

3. Graph the data from the table on the following grid. Graph each surface using a different color. Make a key with the different colors so we know which graph represents which surface.
4. Describe the pattern of change in the table and graph of \((time, number \ of \ colonies)\) for each surface.

<table>
<thead>
<tr>
<th>Surface 1:</th>
<th>Surface 2:</th>
<th>Surface 3:</th>
</tr>
</thead>
</table>

5. What type of function do you think best models the data shown in the table and graph of \((time, number \ of \ colonies)\) for each surface?

6. Find a regression equation that models the data shown in the table and graph of \((time, number \ of \ colonies)\) for each surface. (Use your answer from #3 to determine which type of regression to use.) Round your “a” and “b” values to the nearest hundredth.

<table>
<thead>
<tr>
<th>Surface 1:</th>
<th>Surface 2:</th>
<th>Surface 3:</th>
</tr>
</thead>
</table>
7. Roughly how long will it take for the number of bacteria colonies in each petri dish to reach 400? Explain how you found your answer or show your work.

<table>
<thead>
<tr>
<th>Surface 1:</th>
<th>Surface 2:</th>
<th>Surface 3:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

8. Use your mathematical models of the relationship between time and number of bacteria colonies to answer the following questions. Explain/show your strategies for answering the questions.

   a. Approximately how many bacteria colonies will there be after 15 days? Round to the nearest number of bacteria colonies.

<table>
<thead>
<tr>
<th>Surface 1:</th>
<th>Surface 2:</th>
<th>Surface 3:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
b. After approximately how many days will the number bacteria colonies reach 1,000? Does this make sense in the context of the situation?

<table>
<thead>
<tr>
<th>Surface 1:</th>
<th>Surface 2:</th>
<th>Surface 3:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. Based on the data you collected, which surface has the most bacteria? Explain how you determined your choice.
Lesson Two Summary

It is the author’s intent to provide Lesson Two as an interdisciplinary lesson that engages students in working with real-world problems in mathematics. Similarly, to Lesson One, this lesson requires students to move around the school and to work together to solve mathematical problems. The fact that Lesson Two connects science and mathematics is unique. It would be beneficial for the reader to implement this lesson with a colleague that teaches science. The author encourages teachers to modify the Lesson Two materials to meet their students’ needs and to align with their teaching styles.

Validation of Content

Lessons One and Two were reviewed by Teacher A, a veteran mathematics teacher. Teacher A is the department chair at the school district and teaches College Math (Gemini), Statistics (AP/Gemini), and IB Math/Pre-Calc. Since Lesson Two is cross-curricular, the author also had the lesson reviewed by a veteran science teacher. This teacher is referred to as Teacher B. She teaches Living Environment in the same district as Teacher A.

Validity of Lesson One: Systems of Linear Equations Scavenger Hunt

The feedback provided by Teacher A is paraphrased below:

- One way to incorporate technology into Lesson One would be to use QR codes. Teacher A explained what QR codes are and how to use them. Teacher A added that the students would need to download a QR code extension for their chromebooks or a QR code reader app for their phones.
- Teacher A stated that Lesson One needed a closing activity such as a group discussion or exit ticket that provided student reflection on the activity.
- Lesson One included each type of inquiry that was discussed in the literature review. Teacher A thought the author did a nice job explaining where each type of inquiry was introduced into Lesson One.

- Teacher A asked what the author was looking for in terms of student work. Any teacher who implements Lesson One should discuss the work that needs to be shown with their students before the students begin the scavenger hunt.

- Lesson One could be easily modified for students who are struggling with the concept of systems of linear equations. Any teacher who implements Lesson One could provide their students with less problems or split the questions up among the class (have each half of the class do half of the scavenger hunt). Teachers could also stick to questions in the realm of the first two or three levels of inquiry (confirmation inquiry, structured inquiry, and guided inquiry). Teacher A also suggested that teachers implementing Lesson One could prepare a paper with a list of steps to solve systems of equations as a modification.

- Lesson One could be also be modified for students who would benefit from extension questions regarding the concept of systems of linear equations. For example, the students could be given more questions in the realm of the last two levels of inquiry (guided inquiry and open inquiry). Students could also be given a linear-quadratic system of equations. Teacher A added that a teacher may need to provide some guidance if they provide their students with a linear-quadratic system of equations based on their students prior knowledge. Another way to extend Lesson One would be to give the students a system of linear equations and a point. Then ask, is the point a solution? If yes, plot the point and go to that location. If no, find the solution of the given system of linear equations, plot the point, and go to that location.
- Teacher A discussed that Lesson One could be used to assess students understanding of systems of linear inequalities too. However, this could only occur after the students have had prior lessons on systems of linear inequalities. Also, questions involving systems of linear inequalities would have to be added to Lesson One.

Validity of Lesson 2

The feedback provided by Teacher A is paraphrased below:

- In the lesson plan, the author provided areas that the students may struggle with throughout Lesson Two, but did not address how teachers can help prevent the students from struggling.

- To provide more clarification, Teacher A suggested adding “graph each surface using a different color” for #3 of the reflection questions in Lesson Two.

- Teacher A stated that Lesson Two needed a closing activity such as a group discussion or exit ticket that provided student reflection on the activity.

- Teacher A stated that the following example should be given to students as an expectation for their answer on reflection question #4: “As the ____________ (independent variable- number of days) increases/decreases by ___________ (how much), the ____________ (dependent variable- number of bacteria colonies) increases/decreases by ___________ (how much).” The teacher could even fill in the blanks to show a more concrete example of what they are looking for. Otherwise, student answers may be vague.

The feedback provided by Teacher B is paraphrased below:
- Teacher B mentioned that the author needed to add incubator, 70% EtOH, E.coli (or something similar for a positive control) to the “lesson materials” section of the lesson plan.

- Addressing the warm up, Teacher B suggested asking simple questions, depending on the age group. For example, “List the most disgusting locations in the school. Justify your responses.” Teacher B stated that the justification will most likely lead to a discussion of bacteria and if not, the teacher can lead them toward a discussion of bacteria. Another question Teacher B suggested asking was “What conditions support bacterial growth (generally)? List locations where bacteria lives.” Teacher B liked the idea of the warm up as a think-pair-share exercise.

- Teacher B stated, “From a science teacher perspective, it is also important for the teacher to ensure the students know that failure is typical in science (so don't be discouraged if the experiment doesn't go the way you expect it to). The teacher needs to be aware of that and be ready for alternatives if bacteria doesn't grow, etc.”

- A comment made by Teacher B was, “It would be interesting if you could collaborate with the science teacher because then the students could design the experiment themselves thus making it more student-centered rather than teacher-directed.”

- To address the issue of incorrectly counting bacteria (#2 of where students may struggle in the lesson plan) Teacher B suggested that the teacher presenting the lesson should lead a class discussion about examining the plates. The teacher should address that “it is actually a very real and authentic way for students to learn how scientists decide to quantify data.” As a class, they can determine how to count colonies, what counts (or doesn't count) as a colony, etc.
Overall, Teacher A stated that both lessons met the provided learning objectives and aligned with the purpose of the curriculum. The primary content goal of Lesson One was to create systems of linear equations and solve them using multiple methods. This goal was met based on the questions provided in the scavenger hunt. Teacher A also commented on how the author used Lesson One to draw personal connections for the students. The map of the scavenger hunt was of their school, the questions involved their teachers, and the questions related to their lives at that district. The primary content goals of Lesson Two were to model real-world problems using mathematical equations and determine which model is the best fit of those specific real-world problems. These goals were met by having the students solve problems within an interdisciplinary lesson. Teacher A agreed that a cross-curricular lesson would help students engage in real world problem solving involving mathematics. In addition, Teacher A stated that both lessons are great culminating activities for the given learning objectives and both lessons appropriately fit with the chosen CC math standards.

The main purpose of the curriculum was to provide Secondary Mathematics Teachers with two exemplar inquiry lessons aligned with CC Algebra I Standards. Teacher A stated “I do believe your lessons follow an inquiry-based format and would work with changes in the curriculum. Both concepts are standard mathematical skills students will need regardless of the standards. These inquiry based lessons can also easily be changed depending on the content. You can do the scavenger hunt for any topic especially.”

Teacher A provided some suggestions in her feedback to improve the lessons. The first suggestion Teacher A gave the author was to use QR codes to incorporate technology into Lesson One. To address this change, the author provided QR codes for each of the scavenger hunt questions. The second suggestion Teacher A provided to the author was to include a closing
activity for Lesson One. Since the same suggestion was made for Lesson Two, the author added a final step in the “classroom activities” section of both lesson plans to allow time for student reflection on the activity. The questions for the class discussion are listed in the lesson plan and will provide student reflection on the activity. Teacher A provided other suggestions for Lesson One that depend on the teacher implementing the lesson and on the students participating in the lesson. Therefore, the author did not make changes to the curriculum based on these suggestions.

For Lesson Two, Teacher A recommended that the author add tips to help prevent students from struggling on certain parts of the lesson. The author went a step further and added these tips in the “How Teachers can be Prepared” section for both lesson plans. Teacher A also suggested adding “graph each surface using a different color” for #3 of the reflection questions in Lesson Two. To provide even more clarification, the author also added “Make a key with the different colors so we know which graph represents which surface.” Since the last suggestion by Teacher A was regarding teacher expectations for student answers on reflection question #4, the author did not make any changes to the curriculum. This is something each individual teacher will discuss when implementing the curriculum.

Overall, Teacher B found Lesson Two to be a solid cross-curricular activity. The following changes were made to improve the curriculum based on Teacher B’s feedback. Incubator, 70% EtOH, and E.coli were added to the “lesson materials” section of the lesson plan. To address the issue of incorrectly counting bacteria (#2 of where students may struggle in the lesson plan), the author added a class discussion about examining the plates and that as a class, they can determine how to count colonies, what counts (or doesn't count) as a colony, etc. This was added to the “How Teachers can be Prepared” section of the lesson plan. The author did not make any other changes regarding Teacher B’s suggestions. However, the author recommends
keeping Teacher B’s notes in mind, as they are pertinent to consider when modifying the
curriculum to meet your students’ needs.

**Conclusion**

This curriculum project was designed to provide Secondary Mathematics Teachers with
two exemplar inquiry lessons for Algebra I. It offers two culminating activities; one for solving
systems of linear equations and another for modeling real-world problems using mathematical
equations. The author encourages teachers to modify the curriculum provided to align with their
style of teaching and to meet the needs of their students.

It is the author’s intent to provide this curriculum as an opportunity for students to
collaborate with their peers. In addition, the curriculum is meant for students to engage in real-
world mathematics through cross-curricular activities and problems that specifically relate to
them. This curriculum is aligned to Merrill’s (2002) five principles of instruction and Dana et al.
(2013) five essential strategies of implementing the Common Core State Standards through
inquiry. For these reasons, teachers are encouraged to use an inquiry-based approach in order for
students to explore the mathematics and fully develop an understanding of linear systems of
equations and modeling real-world problems with mathematical equations.

While inquiry-based approaches are typically more demanding than other teaching
techniques, the resulting skills that students acquire are practical for real-life. This curriculum is
designed to develop students inquiry skills: conducting experiments, analyzing data, drawing
conclusions, and collaborating with others regarding those conclusions. Therefore, it is the
author’s hope that students will take away more than a firm understanding of linear systems of
equations and modeling real-world problems with mathematical equations. Students are
encouraged to understand why it is important to work hard to learn mathematics based on the
connections they make between real-life and mathematics; through their understanding of the material and the skills that they develop.

**References**


Markham, T. (2013, May 20). Inquiry learning vs. standardized content: Can they coexist?.


Appendix A
Answer key for Lesson One: Systems of Linear Equations Scavenger Hunt

Name: Key
Date: Algebra I

Linear Systems Scavenger Hunt

**Directions:** Each of you will be paired up with a classmate. You and your partner will be given a map of the school and a QR code. Scan the QR code and solve the problem that is provided. Then graph your answer on the map and go to that location. At that location, there will be another QR code that you need to scan in order to receive the next problem to solve. Each QR code has a symbol next to it. When you first get to a QR code, draw the symbol in the space on the left. Then do all of your work to solve the problem in the space on the right. Circle your final answer. When you end up at the same QR code that you started with, come talk to me.
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Work for each problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>$11x + 8y = -80$</td>
<td>$x - 16 (12) = -208$</td>
</tr>
<tr>
<td>$x - 16y = -208$</td>
<td>$x - 192 = -208$</td>
</tr>
<tr>
<td>$16y + 16y$</td>
<td>$+192 + 192$</td>
</tr>
<tr>
<td>$x = -208 + 16y$</td>
<td>$x = -16$</td>
</tr>
<tr>
<td>$11(-208 + 16y) + 8y = -80$</td>
<td>$(-16, 12)$</td>
</tr>
<tr>
<td>$-2288 + 176y + 8y = -80$</td>
<td>Big Gym</td>
</tr>
<tr>
<td>$184y = 2,008$</td>
<td></td>
</tr>
<tr>
<td>$y = 12$</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cloud</th>
<th>Let $x =$ cost of long-sleeve, $y =$ cost of t-shirt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$2x + 4y = 78$</td>
</tr>
<tr>
<td></td>
<td>$-2x + 2y = 54$</td>
</tr>
<tr>
<td></td>
<td>$2y = 24$</td>
</tr>
<tr>
<td></td>
<td>$y = 12$</td>
</tr>
<tr>
<td></td>
<td>$2x + 4(12) = 78$</td>
</tr>
<tr>
<td></td>
<td>$2x + 48 = 78$</td>
</tr>
<tr>
<td></td>
<td>$2x = 30 \rightarrow x = 15$</td>
</tr>
</tbody>
</table>

*Note: students may get $(12, 15)$ depending on how they assign variables.*
| Heart | $y = -9 + \frac{9}{13}x$  
$y = -\frac{23}{2} + \frac{1}{2}x$  
\([-13, -18]\)  
Art Wing |
|---|---|
| $-9 + \frac{9}{13}x = -\frac{23}{2} + \frac{1}{2}x$  
$-9 + \frac{5}{26}x = -\frac{23}{2}$  
$\frac{5}{26}x = -\frac{5}{2}$  
$x = -13$  
$y = -9 + \frac{9}{13}(-13)$  
$y = -18$ |

| Happy Face | $(5y + 3x = 87) \times 3$  
$15y + 18x = 387$  
$15y + 9x = 261$  
$-15y + 18x = 387$  
$-9x = -126$  
$x = 14$ |
|---|---|
| $(5y + 3(14) = 87$  
$5y + 42 = 87$  
$5y = 45$  
$y = 9$ |
| Faculty Lounge |

58
3x - 2y = 26
3x - 2y = 26
3x - 2y = 26
3x - 2y = -32
\( \frac{3x - 2y}{-29x} = \frac{-32}{58} \)
\( x = -2 \)

3(-2) - 2y = 26
-6 - 2y = 26
-2y = 32
y = -16

\((-2, -16)\)

3x - 5y = 17
y = -7
3x - 5(-7) = 17
3x + 35 = 17
3x = -18
x = -6

\((-6, -7)\)
Nurse

y = 2 - \( \frac{1}{5} \)x
y = -6 - \( \frac{11}{15} \)x
2 - \( \frac{1}{5} \)x = -6 - \( \frac{11}{15} \)x
2 + \( \frac{8}{5} \)x = -6
\( \frac{8}{15} \)x = -8
x = -15

y = 2 - \( \frac{1}{5} \)(-15)

y = 5

\((-15, 5)\)
Big Gym
### Using Inquiry to Teach the Common Core State Standards: Two Exemplars

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>$425y + 127x = 1993$</td>
<td>$x = 5y - 1$</td>
</tr>
<tr>
<td>$x = 5y - 1$</td>
<td>$x = 5(2) - 1$</td>
</tr>
<tr>
<td>$425y + 127(5y - 1) = 1993$</td>
<td>$x = 9$</td>
</tr>
<tr>
<td>$425y + 635y - 127 = 1993$</td>
<td>(9, 2)</td>
</tr>
<tr>
<td>$1060y - 127 = 1993$</td>
<td>Senior Lounge</td>
</tr>
<tr>
<td>$1060y = 2120$</td>
<td></td>
</tr>
<tr>
<td>$y = 2$</td>
<td></td>
</tr>
</tbody>
</table>

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<th></th>
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<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>$y + x = 2$</td>
<td>$-11 + x = 2$</td>
</tr>
<tr>
<td>$4y + 57 = x$</td>
<td>$x = 13$</td>
</tr>
<tr>
<td>$y + 4y + 57 = 2$</td>
<td>(13, -11)</td>
</tr>
<tr>
<td>$5y + 57 = 2$</td>
<td>Volpe's Hallway</td>
</tr>
<tr>
<td>$5y = -55$</td>
<td></td>
</tr>
<tr>
<td>$y = -11$</td>
<td></td>
</tr>
</tbody>
</table>

### Answers will vary.

Here is one possible answer:

- $y = -4 + \frac{5}{16}x$
- $y = 12 - \frac{11}{16}x$

- $-4 + \frac{5}{16}x = 12 - \frac{11}{16}x$
- $-4 + x = 12$
- $x = 16$
- $y = 12 - \frac{11}{16}(16)$
- $y = 1$

(16, 1) → Foyer 1
Appendix B

Answer key for Lesson Two: Bacteria Experiment

Name: ___________________________ Date: ______________

Algebra I Bacteria Experiment

WARM-UP: Individually, answer the following questions in the space provided. When you have finished each question, share your responses with your partner.

1. List a few surfaces that you think have a lot of bacteria on them.
   - door knob
   - cell phone
   - light switch
   - calculator
   - toilet flusher
   - desk

2. List a few surfaces that you think do not have a lot of bacteria on them.
   - windows
   - smart board
   - top of cabinets
   - magnets

3. What do you think will happen to the number of bacteria colonies if we get samples from these surfaces and let them sit in petri dishes for a few weeks?

   The number of bacteria colonies will increase.
Bacteria Experiment Directions

1. Make sure you and your partner have all of the necessary materials:
   - 3 petri dishes with Agar
   - 3 cotton swabs
   - 1 sharpie/marker
   - Tape
   - 2 pairs of disposable gloves

2. State the three surfaces you and your partner will be testing:
   a. cell phone
   b. smart board
   c. calculator

   Answers will vary

3. State which surface you think will have the most bacteria on it: cell phone

4. Put a pair of disposable gloves on, grab a cotton swab, and swab one surface. Then, gently wipe the swab onto the agar in a zigzag pattern. Place the cover on the petri dish and tape it shut.

   Make sure to label the dish with the surface name, today’s date, and your names.

5. Repeat step 4 for the other two surfaces.

6. See me when you are finished with step 5 for further directions.
Reflection Questions for Bacteria Experiment

1. Record the number of bacteria colonies from your petri dishes in the following chart.

<table>
<thead>
<tr>
<th>Time (in Days)</th>
<th>Number of Colonies</th>
<th>Number of Colonies</th>
<th>Number of Colonies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surface 1:</td>
<td>Surface 2:</td>
<td>Surface 3:</td>
</tr>
<tr>
<td></td>
<td>Cell Phone</td>
<td>Smart Board</td>
<td>Calculator</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>------- Saturday -------</td>
<td>------- No record -------</td>
<td>------- No record -------</td>
</tr>
<tr>
<td>6</td>
<td>------- Sunday -------</td>
<td>------- No record -------</td>
<td>------- No record -------</td>
</tr>
<tr>
<td>7</td>
<td>190</td>
<td>4</td>
<td>86</td>
</tr>
<tr>
<td>8</td>
<td>400</td>
<td>6</td>
<td>140</td>
</tr>
<tr>
<td>9</td>
<td>400+</td>
<td>7</td>
<td>300</td>
</tr>
<tr>
<td>10</td>
<td>400+</td>
<td>10</td>
<td>400+</td>
</tr>
<tr>
<td>11</td>
<td>400+</td>
<td>14</td>
<td>400+</td>
</tr>
</tbody>
</table>

*too many to count*
2. Which surface started with the most bacteria? How did you determine this?

All of the surfaces start with zero bacteria because there are no colonies in the petri dish on Day 0.

3. Graph the data from the table on the following grid.

Bacteria Growth on Three Surfaces

Number of Bacteria Colonies

Time (days)
4. Describe the pattern of change in the table and graph of \((time, number\ of\ colonies)\) for each surface.

<table>
<thead>
<tr>
<th>Surface 1:</th>
<th>Surface 2:</th>
<th>Surface 3:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Phone</td>
<td>Smart Board</td>
<td>Calculator</td>
</tr>
<tr>
<td>As the number of days increase by 1, the number of bacteria colonies increases at an increasing rate.</td>
<td>As the number of days increase by 1, the number of bacteria colonies increases at a somewhat steady rate.</td>
<td>As the number of days increases by 1, the number of bacteria colonies increase at an increasing rate.</td>
</tr>
</tbody>
</table>

5. What type of function do you think best models the data shown in the table and graph of \((time, number\ of\ colonies)\) for each surface?  
   Surface 1 \& 3 \rightarrow exponential, Surface 2 \rightarrow linear

6. Find a regression equation that models the data shown in the table and graph of \((time, number\ of\ colonies)\) for each surface. (Use your answer from #3 to determine which type of regression to use.) Round your "a" and "b" values to the nearest hundredth.

<table>
<thead>
<tr>
<th>Surface 1:</th>
<th>Surface 2:</th>
<th>Surface 3:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Phone</td>
<td>Smart Board</td>
<td>Calculator</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(L_1) 1</td>
<td>(L_2) 1</td>
<td>(L_1) 1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>190</td>
<td>11</td>
</tr>
<tr>
<td>8</td>
<td>400</td>
<td>14</td>
</tr>
</tbody>
</table>

\[
a = 3.858771217 \quad b = 2.413512629
\]

\[
a = 1.164912281 \quad b = -2.207017544
\]

\[
a = 0.2796134229 \quad b = 2.180517098
\]
7. Roughly how long will it take for the number of bacteria colonies in each petri dish to reach 400? Explain how you found your answer or show your work.

<table>
<thead>
<tr>
<th>Surface 1: Cell Phone</th>
<th>Surface 2: Smart Board</th>
<th>Surface 3: Calculator</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>bacteria</td>
<td>400 = 1.16x - 2.21</td>
</tr>
<tr>
<td>7</td>
<td>190</td>
<td>+ 2.21</td>
</tr>
<tr>
<td>8</td>
<td>400</td>
<td>+ 2.21</td>
</tr>
<tr>
<td>9</td>
<td>400+</td>
<td>y = 1.16x</td>
</tr>
<tr>
<td>8 days</td>
<td>347 days</td>
<td>1.16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>346.7327586 = x</td>
</tr>
</tbody>
</table>

8. Use your mathematical models of the relationship between time and number of bacteria colonies to answer the following questions. Explain/show your strategies for answering the questions.

a. Approximately how many bacteria colonies will there be after 15 days?

<table>
<thead>
<tr>
<th>Surface 1: Cell Phone</th>
<th>Surface 2: Smart Board</th>
<th>Surface 3: Calculator</th>
</tr>
</thead>
<tbody>
<tr>
<td>y = 0.39(2.41)^15</td>
<td>y = 1.16(15) - 2.21</td>
<td>y = 0.28(2.18)^15</td>
</tr>
<tr>
<td>y = 209565.7209</td>
<td>y = 15.19</td>
<td>y = 33419.9227</td>
</tr>
<tr>
<td>~ 209,566 bacteria colonies</td>
<td>~ 15 bacteria colonies</td>
<td>~ 33,420 bacteria colonies</td>
</tr>
</tbody>
</table>
b. After approximately how many days will the number of bacteria colonies reach 1,000? Does this make sense in the context of the situation?

<table>
<thead>
<tr>
<th>Surface 1:</th>
<th>Surface 2:</th>
<th>Surface 3:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cell Phone</strong></td>
<td><strong>Smart Board</strong></td>
<td><strong>Calculator</strong></td>
</tr>
<tr>
<td>$1,000 = 0.39(2.41)^x$</td>
<td>$1,000 = 1.16x - 2.21$</td>
<td>$1,000 = 0.28(2.18)^x$</td>
</tr>
<tr>
<td>$y_1$</td>
<td>$+2.21$</td>
<td>$y_1$</td>
</tr>
<tr>
<td>$y_2$</td>
<td>$+2.21$</td>
<td>$y_2$</td>
</tr>
<tr>
<td>$1,002.21 = 1.16x$</td>
<td>$1.16$</td>
<td>$1,002.21 = 1.16x$</td>
</tr>
<tr>
<td>$863.9741379 = x$</td>
<td>$1.16$</td>
<td>$863.9741379 = x$</td>
</tr>
<tr>
<td>$\sim 9$ days</td>
<td>$\sim 8.64$ days</td>
<td>$\sim 10$ days</td>
</tr>
<tr>
<td>Yes this makes sense.</td>
<td>This does not make sense in the situation because the bacteria would begin to level off due to lack of nutrients around day 10.</td>
<td>Yes this makes sense.</td>
</tr>
</tbody>
</table>

9. Based on the data you collected, which surface has the most bacteria? Explain how you determined your choice.

The cell phone had the most bacteria growth because the number of bacteria colonies grew at a faster rate.