Fostering Motivation with an

Authentic Task Based Unit on Linear Modeling

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Abstract

This curriculum project was created to provide teachers with additional resources to use when teaching an 8th grade unit on linear modeling. The included activities put an emphasis on grappling with new ideas, communication, and developing understanding through a project using real world mathematics. An embedded goal in the curriculum is to foster student motivation in mathematics. The main topic involves constructing scatter plots, noticing trends in the data, and constructing lines of best fit based on these trends. Recommendations are included by the author for implementing the included activities, as well as a rubric for evaluating the student projects. Aligned Common Core standards are included in the unit plan.

Introduction

In an age of high stakes testing, the secondary mathematics education community is often left fixated on improving student achievement. While achievement is undeniably a crucial goal, the pursuit of achievement tends to overlook several other factors that are necessary building blocks for student success. Considering student motivation to learn mathematics has been suggested as a method for improving student achievement. Motivation, however, is a complex social factor that can be different with every student. One potential reason that students are often not motivated to learn mathematics is that they do not see the purpose for the mathematics they are being challenged to learn. They may feel as though mathematics is some abstract idea that has nothing to do with the world around them. This disconnect can lead students to lose interest in the challenge to learn mathematics.

As teachers of Mathematics, many of us have been asked that frustrating question: “why does this matter?” or “when we are ever going to use this?” The materials presented in this curriculum project were designed to address such questions. Mathematics is a rich subject full of concepts and structures that are foreign to many students. Fostering motivation to learn mathematics is one key step in getting students to pursue achievement in our subject area. For that reason, while the materials presented are tailored to an eighth-grade mathematics classroom, these materials are for all teachers of mathematics, so that we may all be teachers of motivation.

The focus of this curriculum project is to show how using a project-based learning approach with integrated social components can increase student’s motivation to learn mathematics, and in turn put students in a better position to develop mathematical proficiency. The content for this curriculum project is an eighth-grade unit on linear modelling.

Review of the Literature

Authentic Tasks and Project Based Instruction

There is a lack of clarity about what exactly problem solving is and what it should look like. Beswick (2010) noted mathematical terminology that appeared to mean different things when used by their authors despite being used interchangeably. Words such as 'authentic', 'real life', and 'situated' describe a range of tasks spanning from questions with only numbers and symbols all the way to questions given in the form of a word problem (p. 369). Beswick notes an important distinction in some of these problems that would be of use moving forward. One definition of an 'authentic task' is a task that includes no readily made algorithm for reaching the answer (Beswick, 2010, p. 369). Cotic and Zulijan (2009) stated a problem in mathematics is when students are tasked with finding a solution using a set of given information in which they have no existing knowledge of how to connect start to finish. There are two important notes to be made about these definitions. First, the amount of words in the provided task has nothing to do with whether or not it is authentic, there could be a question given only through numbers and symbols that is far more authentic than a given word problem that lacks authenticity because students have access to procedures for reaching an answer. Second, the authenticity of the task is then subject to the current understanding of the student engaging with it. In other words, a task might be unauthentic for one secondary student because they have more understanding than others or they may have access to some convenient procedure. The same task may be much more challenging and authentic for another secondary student because of the absence of those very things. Furthermore, there seems to be nothing suggesting that an authentic task is one taken up by a student in a completely independent manner.

Rassmussen and Marrongelle (2006) showed what proper authentic problem solving can look like during whole group instruction. They referred to them as Transformational Record and Generative Alternative (p. 395, 405). In Short, a transformational record refers to a diagram or graph being constructed slowly during group discussion where, during each step of the creation process, students are prompted to consider the correctness of the decisions they are making. A student may give a correct response early in the process of forming this record, but the point is to allow all students time to consider the given response and how appropriate it may be for the record being developed. Generative alternatives involve the teacher asking students to present different solutions to a task or problem, followed by engaging the whole class in a discussion aimed at discerning what the correct answer is or what a correct answer needs to look like (Rassmussen & Marrongelle, 2006). There are some important attributes of the two tools that make them authentic task models for whole group instruction. Both tools require the teacher to have enough content knowledge to let the students make mistakes and to subtly guide the students towards mathematical proficiency through whole group conversations and through challenging their reasoning in one way or another.

There is also no reason to believe that an authentic task is one that must come down to a single question that can be solved within the context of single lesson or a single class session. Project-based learning is a model of learning that has existed for quite some time in other science, technology, engineering, and mathematics (STEM) fields, as well as subjects like English or art. Cevik (2018) demonstrated that an interdisciplinary use of project-based learning increased student achievement in the STEM fields, as well as increased student enthusiasm for these fields of study. It was also noted that when done properly, project-based learning uses higher order thinking skills and provides a way for students to address complex problems requiring procedures that they may not have developed yet (Cevik, 2018).

A Social Perspective

This may come as no surprise, but according to Sithole, Chiyaka, McCarthy, Mupinga, Bucklein, and Kibirige (2017) there are a multitude of social factors that weigh on our students. They describe factors such as gender, socio-economic status, and ethnicity as playing a role in engagement with the STEM fields. Sithole et al. (2017) claim that the careers of scientists, engineers, mathematicians, technicians, etc. are all traditionally thought of as jobs for middle to upper class white males. They also acknowledge that these fields are considered to be the more challenging fields of study, and as such there is a perceived risk in studying them. They recommend using support centers and learning communities as a means of addressing the problems facing the STEM fields. A learning community is a place or a group of people with which an individual student can discuss problems they are facing in their coursework, work on homework, talk about content with other students, and more (Sithole, Chiyaka, McCarthy, Mupinga, Bucklein, & Kibirige, 2017). There is more to be said about the benefits of establishing learning centers, but the factor worth noting is the *establishment of a culture of learning*.

Previous research into learning centers done by Yvette Solomon, Tony Croft, and Duncan Lawson (2010) reveal some additional findings into the social aspects of learning. Solomon, Croft, and Duncan found that students who participated in learning centers tended to shift their general approach to learning (Solomon, Croft, Duncan, & Lawson, 2010). Subjects came from classrooms run with a lecture format, where instruction was fast paced, discussion was minimal, and asking questions was risky because students felt exposed upon doing so. Solomon, Croft, and Duncan found that students in the learning centers began to see each other as participants in a culture of learning and mathematics, and in turn began to identify those same attributes within themselves. According to the group, the benefits of the learning centers transcended the simple act of students helping each other with individual math problems. Additional benefits included an increase in student ownership of learning and an increase in participant identity (Solomon, Croft, Duncan, & Lawson, 2010). In other words, the learning centers made students feel as though they were more than just an audience to their education, they were involved in it and responsible for the learning that was taking place.

Solomon et al. (2010) and Sithole et al. (2017) recommended learning centers as an external support system to the classroom. However there doesn't seem to be any sufficient reason why the culture of learning and cooperation established in those external support systems could not also be established within the classroom. For example, Gay (2002) provided recommendations for establishing a community of learners in a diverse student population. Gay acknowledges that students in our classrooms come from a variety of backgrounds, and in turn bring a lot of different things into our classroom. She also notes that many students of color come from cultures where the success of the group is more important than the success of any individual. (Gay, 2002) According to Gay, every student walking into our classrooms is capable of working cooperatively, some are even exceptional at it. Students need to know how to communicate their ideas to others and to interpret what is being communicated to them in return. Additionally, Gay claims that each and every student needs to be held to a high standard of success and needs support in meeting that standard. Students need a teacher who believes in their intellectual capabilities and who pushes them to do their best every day without ignoring or demeaning their social or cultural background. (Gay, 2002)

Motivation and Interest

Motivation and Interest in mathematics involve a complex network of social factors that lead to students wanting to engage with mathematics in the classroom. Frenzel, Goetz, Pekrun, and Watts (2010), state that interest, specifically, is a motivational factor involving the yielded happiness with engaging in an activity. Frenzel et al. found that not only is the loss of interest in mathematics at the secondary level a very real trend, but it is a robust process that takes time and involves a variety of social factors like family, friends, gender, and perceived ability in mathematics (Frenzel, Goetz, Pekrun, & Watts, 2010).

A review of the literature suggests that there are many different types of motivation, the most important of which for furthering this purpose are discussed by Herges, Duffield, Martin, and Wagerman (2017): intrinsic and extrinsic motivation. Extrinsic motivation concerns motivation for the rewards of completing a task. This can range anywhere from getting good grades, getting some sort of prize, or being praised by a teacher, parent, or peers. While extrinsic motivation has had its place in the American educational system, and likely will not be disappearing anytime soon, it is not the kind of motivation that is of most concern to this curriculum project. Intrinsic motivation, on the other hand, involves factors that drive a student on a much more personal level. A student that is intrinsically motivated may be taking a test to challenge themselves as opposed to doing so for a grade. Furthermore, students who are intrinsically motivated may be engaging in mathematics activities for curiosity or a love for mathematics, and not explicitly for some perceived reward (Herges, Duffield, Martin, &

Wagerman, 2017). Fostering this form of motivation can be difficult in the mathematics classroom as students need to believe that not only is there some purpose and benefit to engaging with a mathematics activity that has been put before them, but they must also believe that they have the ability to succeed in the given task. A student's confidence, and in a deeper sense their self-efficacy, is an important motivational factor. Among the more challenging students there are a variety of motivational approaches that need to be utilized to increase confidence. Where one approach may work well for one student, it may not work at all for another (Newman, 2009).

Ahmed, Minnaert. van der Werf, and Kuyper (2010) hoped to verify previous research findings as well as verify the common conception of how motivation impacts students in the classroom. Through the measurement of several socioemotional variables, Ahmed, Minnaert, van der Werf, and Kuyper concluded that a complex network of motivation aspects including perceived support from parents, perceived support from teachers, perceived support from peers, and a perception of competence, all had an impact on how the students in the study performed on mathematics tasks. Motivation influences mathematical achievement (Ahmed, Minnaert, van der Werf, & Kuyper, 2010). Riconscente (2014) found that among other important variables like student perceptions of the teacher's ability to explain mathematics, "perceived teacher caring was positively related to Latino students' achievement" (p. #) Additionally, it was found that changes in these variables had a positive impact on "interest and self-efficacy in mathematics" (Riconscente, 2014. P. 67).

Unit Plan and Pacing: Increasing Student Motivation with Linear Modeling

Standards:

NY-8.F.4	Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values
NY-8.F.5	Describe qualitatively the functional relationship between two quantities by analyzing a graph *(e.g., where the function is increasing or decreasing or when the function is linear or nonlinear)*. Sketch a graph that exhibits the qualitative features of a function that has been described in a real-world context.
NY-8.SP.1	Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.
NY-8.SP.2	Understand that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear

	association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line.
NY-8.SP.3	Use the equation of a linear model to solve problems in the context of bivariate measurement data, interpreting the slope and intercept.

Recommended Pacing:

The recommended time frames for the activities below may not reflect a standard single day lesson. Time guidelines were estimated using a 40 minute bell schedule. Teachers are encouraged to use their best judgement in relation to their students when deciding how much class time to devote to each activity.

Activity Name		Recommended Class Time
1	Discussion Activity: Paper Bridges	80-120 minutes
2	Notes: Line of Best Fit	40-60 minutes
3	Project: Individual Inquiry (Start)	80-160 minutes
4	Peer Review and Fixes and Reflections	Mixed in with Project Start
3 (cont.)	Project: Individual Inquiry (Refining)	40-80 minutes
5	Assessment: Presentations	At teacher discretion

<table>
<tr><td>Activity number: 1

Activity name:

Discussion Activity: Paper Bridges</td><td>Materials needed:
Copies of the Discussion activity handout.
Undamaged paper (about 10 sheets per group)
Pennies (about 150-200 per group)
Rulers (recommended)
Textbooks to put bridges on (recommended)
Computers (optional)</td></tr>
<tr><td colspan="2">Description:

Students will work in groups of 3-4 students to build bridges with various numbers of layers, testing the strength of each using pennies as a test weight. Full class discussion should be used before the implementation of the experiment, as well as after the experiment.</td></tr>
<tr><td colspan="2">Objectives:

At the end of this activity, students will be beginning to develop understanding about how real life data does not always fit into perfectly linear relationships. Furthermore, students should be developing ideas about how to use trends in data to make predictions.</td></tr>
</table>

Implementation notes:

It is important to remember that this is a discussion activity, even if the provided handout mostly involves the experimenting component. Before setting students loose to experiment, it is important to outline the expectations and get them thinking about what exactly they will be doing. Try designing a bridge style as a class that each group of students will follow. How will all of the groups be expected to design their bridges? Could an unfolded piece of paper support any weight? Recommendations at this point of the activity would be to have students do a little bit of research online about designing paper bridges, or to find a video to show the whole class. Once the discussion has been had, the rules for bridge building should be written down and displayed so that groups will all be building similar bridges and will have comparable data.

Once the materials have been distributed to each of the groups and students are asked to begin the experimentation part of the activity, the instructor should be circulating the room and checking in with groups. It is important to allow students the time to grapple with this experiment and the questions that follow, so while circulating, the instructor should refrain from interjecting themselves too much into each group's progress. Checking in with groups as an instructor is a way of showing teacher caring. Many instructors care about the progress of their students, this is simply a method of showing it. Showing teacher caring is a researched method of improving student motivation and achievement (Riconscente, 2014).

Once all of the groups have completed the experimentation, the instructor should bring the class together to discuss the three questions:

- Does the relationship shown by your data appear to linear? Briefly explain your response.
- Suppose you could somehow use half of a layer of paper in your bridge. How many pennies would you predict that a bridge with 2.5 layers could hold? How did you come to this number?
- Suppose we wanted to build a bridge with 1000 layers of paper. We obviously don't have the time or paper for that, but is there a way that we could predict how many pennies that bridge could hold?

In all three of these, the goal of the instructor should be to get students to think about patterns that exist in the data they have collected and how they can use these patterns to make predictions. It is important to give each student an opportunity to add to the conversation in a low risk way.

Name_________________________ Date_________________________

Discussion Activity: Paper Bridges

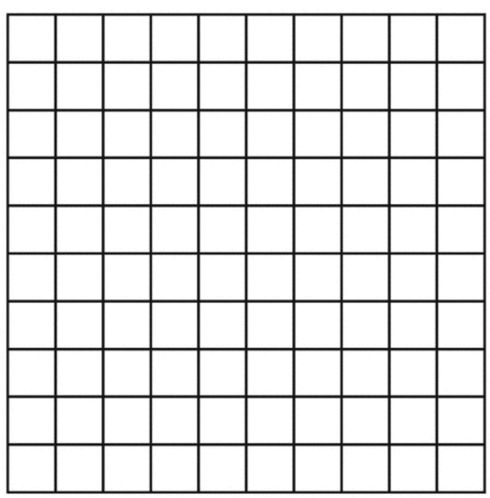
The Problem:

Joseph and Grace are engineers working to construct a new bridge. They are debating about how the thickness and strength of a bridge are related to one another. Grace thinks the relationship is linear and Joseph does not.

The Directions:

Experiment using paper as your construction material and pennies as your test weight to decide which person is correct. Use the provided grid and table to record your results. Then respond to the questions on the back of this page.

# of Paper layers					
# of Pennies					



1. Does the relationship shown by your data appear to linear? Briefly explain your response.

2. Suppose you could somehow use half of a layer of paper in your bridge. How many pennies would you predict that a bridge with 2.5 layers could hold? How did you come to this number?

3. Suppose we wanted to build a bridge with 1000 layers of paper. We obviously don't have the time or paper for that, but is there a way that we could predict how many pennies that bridge could hold?

Activity number: 2 **Activity name:** Notes: Line of Best Fit	**Materials needed:** • Copies of the Line of Best Fit handout. • A sufficient amount of rulers or straight edges.

Description:

The class will use the provided to note sheet to develop ideas concerning linear models and lines of best fit. This should be used as a transition tool, so that students can establish purposeful procedures from their discussion in the paper bridge activity prior to engaging in the real world data project.

Objectives:

At the end of the activity, students should have access to the procedure of drawing a line of best fit. They may not fully understand it yet, though hopefully the notes, the discussion, and their prior knowledge of linear functions have helped them begin to understand the purpose for the procedure. Additionally, students should have some notion of when a line of best fit they have drawn is a good model, and when it is not.

Implementation notes:

The note activity is a more traditional approach to delivering mathematics instruction. It must be noted that the activity is transitional, it is essential to incorporate ideas from the paper bridge activity when discussing the need for a line of best fit. When going through the questions, one recommendation is to mix independent work time with class share out. Particularly for the end of the note sheet (the practice section), one recommendation for the instructor is to give students time to practice drawing lines of best independently and then, for each scatter plot, have multiple students show their work in front of the class. Take the time to allow multiple students the opportunity to share out and express their understanding, and then talk. The discussion thereafter about “which line is better and why” is essential for developing ideas about what makes a linear model good, or better than another.

Name______________________________ Date_____________________

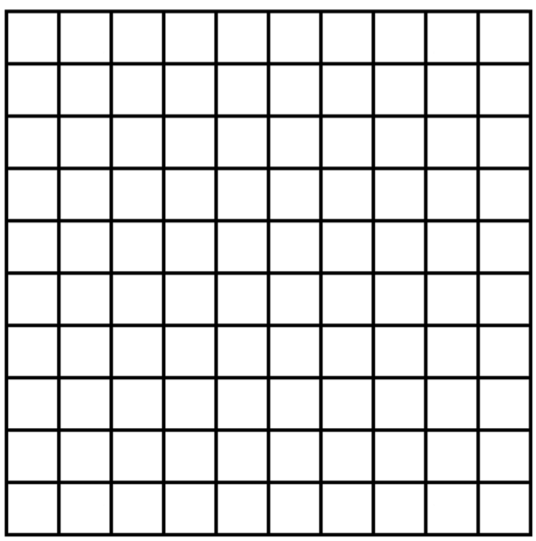
Notes: Line of Best Fit

Vocab: A **Line of Best Fit** is a line we draw using a scatter plot of data. The line should follow the trend formed by the data.

Directions: Construct a line of best fit for the following data representing the height of an oak tree that was measured over several weeks.

Weeks	0	1	3	4	6	8	9
Height (feet)	1.8	2	3.1	3.3	3.5	4.3	5

Tips from the Teacher: Try and get half of the data points below the line and half of the data points above the line while still following the trend of the data. If possible, make sure your line goes through some coordinate lines.



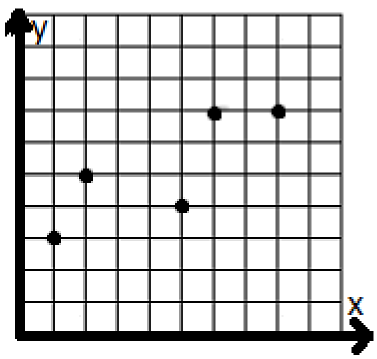
a. What is the slope of this line? What does this mean about the growth of the tree?

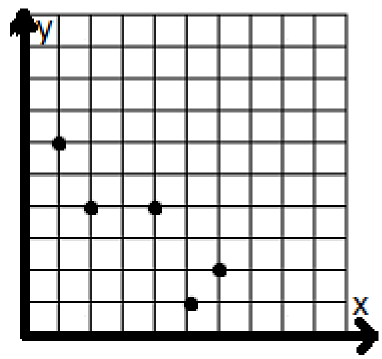
b. What is the y-intercept of the line of best fit?

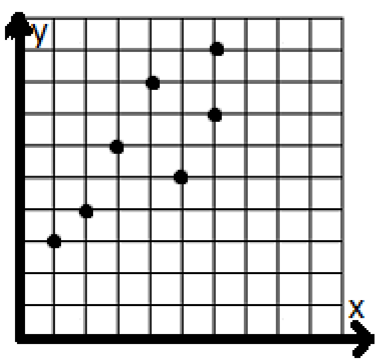
c. Write an equation for the line of best fit that you have graphed.

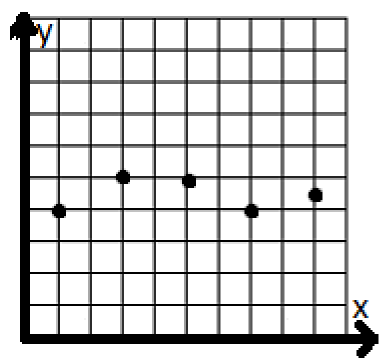
d. Using the model that you have developed, about how tall will the tree be after 40 weeks?

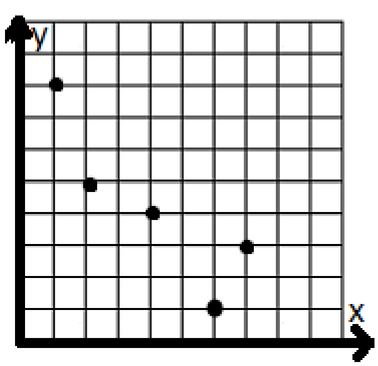
Practice: For each of the following, sketch a line of best fit.

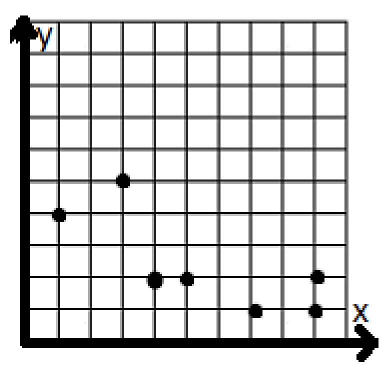












<table>
<tr><td>Activity number: 3

Activity name:

Individual Inquiry Project (Start through Presentation)</td><td>Materials needed:
Copies of the initial directions
Plenty of graph paper.
A sufficient amount of rulers or straight edges.
Computers with internet access (highly recommended).</td></tr>
<tr><td colspan="2">Description:

Students will be researching real world data sets online for the purpose of creating scatter plots that they will model with linear functions. Students will then use their lines of best fit to write linear functions modeling the data. This will provide students with a chance to make sense of the procedures introduced in the previous lesson on lines of best fit, as well as to practice this procedure purposefully.</td></tr>
<tr><td colspan="2">Objectives:

At the end of the first part of the project, students should have had more practice with graphing scatter plots and lines of best fit to further deepen their understanding. Additionally, students should be using their linear models to write and respond to a question concerning the relationship between the variables they chose to focus on from the real world data of their choosing.</td></tr>
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Implementation notes:

The first part of the individual inquiry project will most likely be the most time consuming part of both the project itself and the entire unit. It is recommended to prepare the physical and digital materials to be used well in advance of having students begin the project and to ensure that students have full access to any digital materials that will be provided to them, as many school districts will block student access to a variety of websites for a variety of reasons. One helpful suggestion is to gather some acceptable sites for students to pull data from and to then suggest students use these sites to look for data sets. Checking a search engine for ‘real world data sets’ or something specific like ‘car data’ or ‘sports data’ will help find these resources. Having students search through site after site looking for a data set to their liking is not essential. The goal is for students to be using data concerning something of their interest, not to have students sifting through website after website looking for perfect data. The instructor may wish to modify the activity by making copies of online data sets if a set of computers with internet access are not available.

Once students have found their data they should begin drawing up a scatter plot, drawing in a line of best fit, and writing an equation based on their line of best fit. At this point in the project students may have difficulty writing a question about their data that could be answered using a model, so one potential modification would be to have students wait to write a question until they have had more time to work with their data, talk to a partner, and conference with the instructor. Teacher actions at this time should be limited to circling the room, gathering informal information about student progress, and provoking students to think deeper about the task in front of them. Students may wish to ask for help or advice during this early portion of the project. Remember, grappling with new ideas and engaging in the project is a good way to promote higher order thinking (Cevik, 2018).

There will be a designated period of time for students to conference with the instructor on their work after talking about it with their peers, a little bit of productive struggle before those conferences will make those conversations all the more beneficial for student understanding, and quite possibly student motivation as well.

Name_______________________ Date_____________________

Project: Individual Inquiry

Background:

Our work with the paper bridges has shown us that patterns can exist in the real world that might not be perfectly linear but are close enough for us to build some kind of a model. The real world is full of instances like this.

Directions:

Begin by:

- Browsing the web for data sets. Try and pick one that is about something you care about.
- **Write a question that could be answered using a model.**
- Find a way to plot the data.
- Once the data has been plotted, try and find any patterns that you can.
- Use a line to model the data as best you can.
- Write an equation for the line that you have drawn.

Things to consider:

- There will be many times throughout this process where you may feel “stuck”. That is okay. If that is how you feel, find someone to talk to about what you are doing and why you feel “stuck”.
- Even if you don’t feel “Stuck”, there will be designated times throughout this process where you will need to talk to a partner or two, talk to a teacher, and do some reflecting. Be ready to talk and to listen to others.
- Take your time, think carefully about what you are doing and why you are doing it.

The End Product:

After you have done all the hard work of creating a model for your data set, you will be creating a short presentation including a description of what your data represents, your data, a data plot, and your linear model that you will deliver to the class at some point.

Name___________________________ Date_____________________

Checklist: Individual Inquiry

Directions: Use the following checklist to help guide you through developing your model.

To do:

Task	Check
I have found a data set online about a topic I like that I can use to plot data.	
I have filled out the *Individual Inquiry Project Proposal* form on this data set.	
I have written a question that could be answered using a model from this data set.	
I have plotted the data.	
I have drawn a line of best fit from this data.	
I have written the equation of my line of best fit.	
Next, begin the peer review process with a partner. You will need the *Peer Reviews: Individual Inquiry* sheet.	

Name______________________ Date_______________________

Individual Inquiry Project Proposal

I want to explore the relationship between:

_____________________________ and _____________________________

Using data from:

Name______________________ Date_______________________

Individual Inquiry Project Proposal

I want to explore the relationship between:

_____________________________ and _____________________________

Using data from:

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Activity numbers: 4 and 5

Activity names:

- Peer Review: Individual Inquiry
- Fixes and Reflections: Individual Inquiry
- Assessment: Individual Inquiry Presentation

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Materials needed:

- Copies of each hand out.
- Same materials as activity 3 (for and fixes).
- Computers with access to presentation software and graphing software or websites (recommended).

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Description:

Students will be looking over their work from the start of the project with a few partners, followed by the instructor. After each review of their work, students will reflect on any changes that were recommended to them. Students will then make any necessary corrections to their work before beginning to design a presentation. Finally, students will deliver their presentations to the class.

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Objectives:

By the end of activities 4 and 5, students will have completed their individual inquiry project and presentation. Students will have engaged in the editing process, complete with reviews by their peers and their instructor. Students will also have delivered their findings to the class. Presentation of student work, along with any informal observation during activity

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4, will serve as evidence of progress in student understanding. A recommended rubic for grading will be provided.

Implementation notes:

The important principles behind the peer review, the teacher review, and the presentation are that specific kinds of socialization within the classroom can be good. Particularly, providing opportunities as an instructor to show your students that you care about them as individuals and their progress as learners has noted benefits (Risconscente, 2014).

From a time management standpoint, it may be beneficial to have students begin working on peer reviews as soon as they complete the work from the start of the project, even if there are some students in the class that have not yet finished their scatter plot and linear model. The instructor should preface that getting honest and effective feedback on peer reviews is an important way to catch any mistakes or oversights that may have been made throughout the process thus far. When students peer review, they will pair off to review and discuss each other's work. One recommendation for this part of the activity is to arrange the seats in part of the room into pairs to create a designated space for partner collaboration.

Once students have completed the peer reviews they should be looking to conduct a review with the instructor. The main objective of this review is to go over the student's work with them, make sure they understand what they have done, and make sure they understand where they should be going next. The teacher review activity is not only a great chance to conduct some informal assessments on each student, but also acts as a chance to develop and reinforce relationships with students.

At the discretion of the instructor, students can begin work on their presentation after completing the teacher review activity. What the student presentations look like is up to the instructor. Some recommended characteristics are listed in the project presentation handout and include the scatter plot, a line of best fit, the equation of the line of best fit, and a question that could be answered using their model. One recommendation for this is to have students replicate the work they may have done on paper with digital graphing software and to use this to make graphs for their presentation. Alternatively, students could take pictures of their work to be inserted into presentations, or have their worked scanned to be put in their presentations.

Presentations will act as the assessment for the unit, but how this is done is left to the instructor. One alternative to having students come to the front of the room is to have students insert audio into their presentations, organized into a webpage by the instructor, and then to have the whole class browse through all of these presentations. Scoring of the presentations is also up to the instructor, there is a recommended rubric in the Appendix section.

Name__________________________ Date_____________________

Peer Reviews: Individual Inquiry

Directions: Part of the process of creating anything, whether it is a presentation, an essay, a work of art, etc., is to discuss your thoughts with someone else. In order to make your model and the presentation that will follow, as best as it can be, you will need to talk to a partner or two. Find a partner, look over their work while they look over yours. Then respond to the questions below. Once you have done this for one partner, find a new partner and repeat the process.

Partner name:____________________________

What is one suggestion that your partner made for your model?

What is one thing your partner liked about your work that they want to see in your presentation?

Based off of the talk you had with your partner, what is one thing that you are going to change?

Partner name:___________________________

What is one suggestion that your partner made for your model?

What is one thing your partner liked about your work that they want to see in your presentation?

Based off of the talk you had with your partner, what is one thing that you are going to change?

Directions: After you have talked to two different partners and completed this form, find a time to sit down with your teacher and discuss your work so far, as well as any changes you might want to make to your work before you begin to create your presentation.

Name________________________________ Date_____________________

Fixes and Reflections: Individual Inquiry

Directions: Sit down with your teacher and talk about your work so far. Respond to each of the following questions, and be sure to make use of the extra space at the bottom of the page to record any additional thoughts not covered by these questions.

What was one thing from your model that you like and want to keep for the presentation?

What was one suggestion your teacher made that you are going to use for the presentation?

Was there any suggestions that your teacher made that you disagree with?

Was there anything else that came up in your conversation with your teacher that you believe is important?

Name___________________________ DeRue________________________

Assignment: Individual Inquiry Presentation

Directions: At this point, you should have already found a data set and used it to create a linear model (in the form of a line of best fit and an equation to match). You should also have talked about your ideas with a few partners as well as with your teacher. Lastly, you should have taken some time to go back and make any necessary adjustments to your model that came up when you talked about it with others. You will now need to make a short presentation on your model.

Things to include:

Check	Description:
	A title slide.
	A brief overview of what your original data is about and why it matters to you.
	The original data, in the form of a scatter plot.
	The line of best fit drawn onto the scatter plot.
	The equation for your line of best fit.
	The question you asked about your data at the beginning.
	An answer to the question that uses your model to answer.
	A reference slide that shows where your data came from, as well as any other sources you may have needed for the presentation.

Validity

The curriculum was delivered to two middle school classrooms in November and December of 2018 by the author. Students were then asked to provide some feedback that would inform the effectiveness of the curriculum in motivating students. Evidence from this feedback as well as observations by the author would suggest that the curriculum did motivate students as intended.

Some noteworthy comments from students about the curriculum was that:

- "I liked it because it was not just an activity where you write on a piece of paper but you actually got to do the activity in real life."
- "I liked doing the paper bridges because it was a break from paper and pencil work."
- "I really like the individual projects. I think it was challenging in some parts and some not. Everything went really well."
- "I think that phase one and two of our individual projects [activity 4 and 5] made me really happy, because I could work on my own but ask others for help if needed."

Students were also asked to give feedback about what they would change about the project and its delivery as well as parts of the project that did not go well. Some noteworthy comments were:

- "For the paper bridges I would have made sure we had enough pennies so that one bridge could hold a lot more."
- "I think it was fun but I wish we could have done our own strategy. [activity 1]"
- "It was difficult to arrange the data in the graph because of the obscure numbers."

Reflections

Some alterations to the curriculum are provided based off of the feedback from students as well as observations by the author.

- Activity 1: Make sure to prepare more materials than previously suggested. Some students may want to design their own bridges instead of agreeing to one common design as a class. Doing so would not take any conceptual or motivational aspects away from the activity, it will just allow each group to have data that varies more from other groups. Student bridges could be far stronger if they decide to create a bridge with more strength than anticipated.
- Activity 2: Allow more time to have discussion. The instructor found that when students began to engage in discussions about what made a good line of best fit (at the end of the notes) the recommended 40-60 minutes was not enough to have high quality discussion that provoked higher order thinking.
- Activity 3-5: Be prepared to engage in a lot of one on one conversations. Feedback from the students suggested that one of the things they appreciated the most is that they were given the time to sit down with the instructor, go over their work, and fix and mistakes that they may have made. Additionally, the author recommends having a backup plan for students who may not be capable of delivering a presentation for a reason such as severe anxiety.

These recommendations are based off of the delivery of the curriculum by the author. Instructors are encouraged to make modifications and alterations that they feel is necessary based off of their knowledge of their students.

Conclusion

The topic of modeling lends itself to a discussion about the real world. This curriculum project was created to provide teachers with additional resources to use when teaching 8th grade linear modeling. The activities were designed to emphasize grappling with new concepts, mathematical discourse, and teaching using project based learning and real world mathematics. It is the author's hope that this curriculum can be used by other teachers in their classrooms as well as to inspire a focus on teaching in ways to motivate learning. Teachers should be encouraging students to experiment, analyze, communicate, and reflect when faced with a problem beyond their current understanding.

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Appendix

Notes on Activity Keys:

The nature of this curriculum means that many of the activities provided do not have a singular correct answer. As such, a suggested answer key is provided for the back page of activity 1, and all of activity 2, as well as a suggested grading rubric for activity 5. As suggest in the lesson guides, instructors should be focused on what students are saying to the class and to each other, and guiding the conversations accordingly.

Activity 1 Key:

1. Does the relationship shown by your data appear to linear? Briefly explain your response.

<u>Response for discussion:</u> (assuming the trend was about 30 pennies per layer of paper) The data does not appear to be linear since it does not make a straight line and there does not appear to exist a constant rate. The data does appear to look roughly look like a line, however, and appears to almost have a rate of 30 pennies per layer of paper.

2. Suppose you could somehow use half of a layer of paper in your bridge. How many pennies would you predict that a bridge with 2.5 layers could hold? How did you come to this number?

<u>Response for discussion:</u> (assuming the trend was about 30 pennies per layer of paper) Based on the scatter plot, at 2.5 layers of paper, the bridge would probably be able to hold about 75 pennies.

3. Suppose we wanted to build a bridge with 1000 layers of paper. We obviously don't have the time or paper for that, but is there a way that we could predict how many pennies that bridge could hold?

<u>Response for discussion:</u> (assuming the trend was about 30 pennies per layer of paper) Since the scatter plot does not extend to 1,000 layers, we can use the equation $y = 30x$, where "y" is the number of pennies and "x" is the number of sheets of paper, to approximate that the bridge could hold about 30,000 pennies if it had 1,000 layers.

Activity 2 Key:

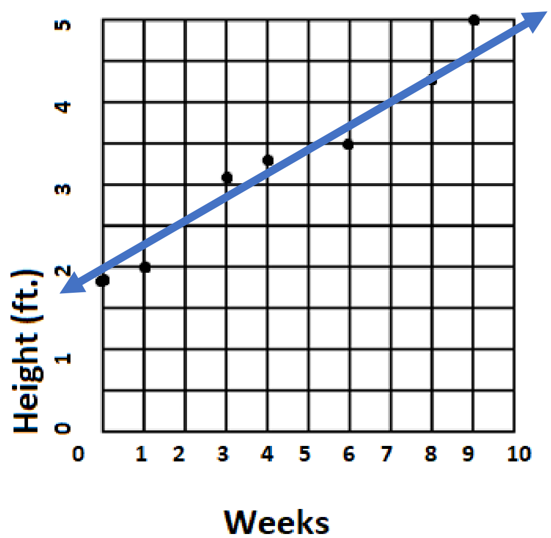
Notes: Line of Best Fit

Vocab: A **Line of Best Fit** is a line we draw using a scatter plot of data. The line should follow the trend formed by the data.

Directions: Construct a line of best fit for the following data representing the height of an oak tree that was measured over several weeks.

Weeks	0	1	3	4	6	8	9
Height (feet)	1.8	2	3.1	3.3	3.5	4.3	5

Tips from the Teacher: Try and get half of the data points below the line and half of the data points above the line while still following the trend of the data. If possible, make sure your line goes through some coordinate lines.



a. What is the slope of this line? What does this mean about the growth of the tree?

Answer: $\frac{\Delta y}{\Delta x} = \frac{2}{7}$, so the tree grows at an approximate rate of $\frac{2}{7}$ feet each week.

b. What is the y-intercept of the line of best fit?

Answer: The line intercepts the y-axis at $y = 2$.

c. Write an equation for the line of best fit that you have graphed.

Answer: If "y" represents height of the tree in feet, and "x" represents the weeks that have passed, as the graph suggests, the line of best fit has the equation:

$$y = \frac{2}{7}x + 2$$

d. Using the model that you have developed; about how tall will the tree be after 40 weeks?

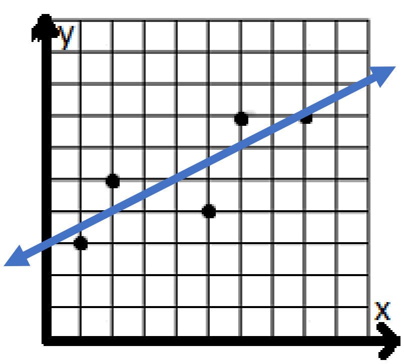
Answer: We can substitute 40 weeks into the equation:

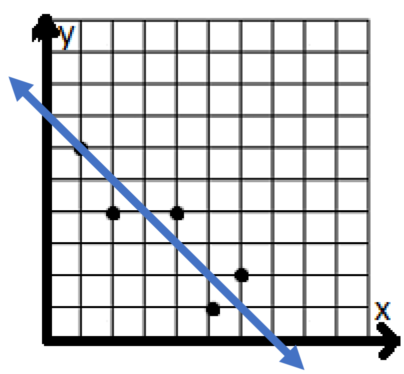
$$y = \frac{2}{7}(40) + 2$$

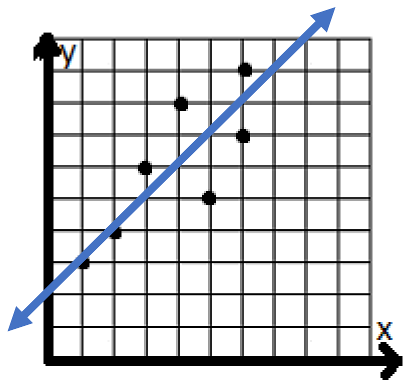
$$y = \frac{80}{7} + 2$$

$$y \approx 18.43\ feet$$

Practice: For each of the following, sketch a line of best fit.



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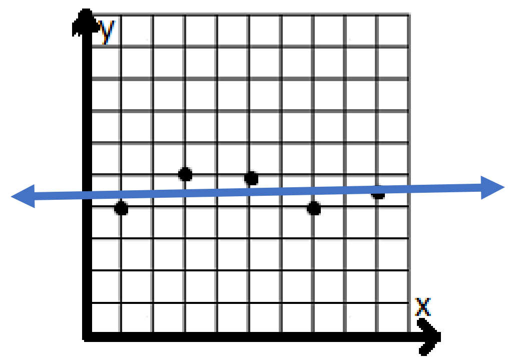
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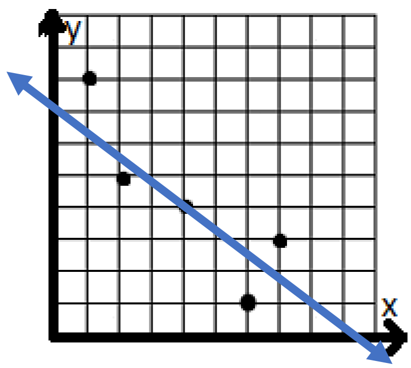
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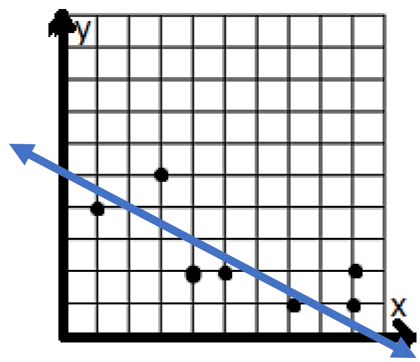
y
x

Activity 5 Rubric:

	Content	Organization	Delivery
Unacceptable	Student's model shows little to no effort. There are mistakes with various parts of the model and question that did not necessarily come from each other.	Student's presentation is poorly organized, contains multiple grammar and spelling errors.	Student refusal to deliver presentation.
Developing	Student's model shows effort. There may be a few mistakes in the scatter plot, equation, or question, but mistakes may have carried from one part to the next.	Student's presentation is organized well enough to be understood, but still contains grammar and/or spelling errors.	Student delivery is difficult to hear, and ideas are not all explained verbally, but effort was clearly made to deliver the presentation.
Acceptable	Student's model shows no clear or concerning mistakes. The question and response show a basic understanding of the purpose the linear model.	Student's presentation is organized well enough to be understood and contains no obvious spelling or grammar errors.	Student delivery is audible to everyone, and the basics of each variable and idea are explained.
Proficient	Student's model shows no mistakes. The question and response show a deeper understanding of the linear model, linear functions, and the data upon which the model was built.	Student's presentation is well organized and aesthetically pleasing. There are no spelling or grammar mistakes, and effort was obviously put in to the looks of the presentation.	Student delivery is perfectly audible to everyone in the room, and the student goes above the minimum requirements to explain their variables and how they appear to be related.