Using Equations to Model Real-World Situations

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Overview of UbD

UbD Template 2.0

<table>
<tr><th colspan="3">Stage 1 Desired Results</th></tr>
<tr><td>ESTABLISHED GOALS

HSA.CED.A.2
Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

HSA.CED.A.4
Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.</td><td colspan="2">Transfer
Students will be able to independently, wisely and flexibly use their learning to…
create an equation in two or more variables that represents relationships between quantities.
solve a problem within that situation using the equation and graph to gain more information.
solve equations for a specified variable in order to highlight a quantity of interest and use that rearranged equation to gain new information about a real-life situation.</td></tr>
<tr><td></td><td colspan="2">Meaning</td></tr>
<tr><td></td><td>UNDERSTANDINGS
Students will understand that…
equations can be used to represent and model real-world relationships.
the situation of the problem will affect the type of function that is used (linear, quadratic, etc.) and the form of equation that is used.
the equation and resulting graph used to represent a situation can be used to predict future events regarding the relationship between the quantities, but that it may only be appropriate in representing the information on a specified interval.
solving an equation for a specific variable helps us more easily find the solution to an unknown</td><td>ESSENTIAL QUESTIONS
Why do we need equations?
How can we use equations to model real-world relationships?
How do we know what form of the equation would be best to use?
How can I use my equation and graph to interpolate or extrapolate more information?
Why do we need to rearrange equations/formulas?</td></tr>
</table>

	variable/quantity when another variable/quantity is known. ● rearranging equations/formulas helps us to more easily graph an equation and use that graph to predict future events.	
	Acquisition	
	Students will know… ● and be able to define the relationship between two quantities. ● and be able to define the unit vocabulary (slope, y-intercept, coordinates, slope-intercept form, point-slope form, standard form, regression line). ● and be able to state why the equation would be better used in a new form.	*Students will be skilled at…* ● determining which quantity should go on which axis. ● determining an appropriate scale for their graph. ● plugging in known information in order to calculate new information. ● finding slope given a graph or given two points. ● creating equations in each form given two points or given a graph.
Stage 2 - Evidence		
Evaluative Criteria	**Assessment Evidence**	
Performance Task 1 Rubric Performance Task 2 Rubric	PERFORMANCE TASK(S): ● Performance Task 1: Written Proposal of sale price of a home ● Performance Task 2: Video recording of conversation with new realtor	Examples: Peformance Task 1 Performance Task 2
Student Reflection Rubric Quiz/Worksheet answer keys to assess skill and knowledge acquisition	OTHER EVIDENCE: ● Student Reflection ● Various worksheets and in-class assignments/activities ● Quizzes ● Various Exit Tickets	Examples: Pre/Post Test Forms of a Line Quiz Parallel and Perpendicular Lines and Regression Lines Quiz
Stage 3 – Learning Plan		
Summary of Key Learning Events and Instruction The learning activities in Stage 3 need to be aligned with the goals from Stage 1 and the assessments from Stage 2. Activities will be done using direct instruction, discovery-based learning, hands-on activities, and student		

reflection/self-assessment. Learning will begin with a "hook" activity to gain student interest, then students will learn about slope and the three forms of lines. Students will then organize their thoughts on the forms of lines, and learn about scatter plots and trend lines. All of these activities will help them gain the knowledge they will need to complete the performance assessments.		
To answer the question: **What learning experiences and instruction will enable students to achieve the transfer goals?** All learning activities will lead students to achieving the transfer goals, but specifically, engaging students in the performance tasks will help them transfer their learning to new situations.	*To answer the question:* **What learning experiences and instruction will enable students to achieve the meaning-making goals?** The learning experiences that will enable students to achieve the meaning-making goals are the cups stacking initial "hook" activity, the slope discovery activity, standard form discovery activity, the use of graphic organizers to help students organize their thoughts on the three forms of lines, the scatter plots and trend lines activity, and the student-led discussion of how equations and graphs of lines are used in real-life.	*To answer the question:* **What learning experiences and instruction will enable students to achieve the acquisition goals?** The learning experiences that will enable students to achieve the acquisition goals are direct instruction and drill and practice on each form of a line and converting among forms, participating in Kahoot games for slope and writing equations in each form, and using cooperative learning groups for practicing graphing and writing equations in each form.

Project Overview

Problems Identification

The purpose of this project is to design an instructional unit on linear equations in Algebra 1 by adopting the framework of *Understanding by Design* (UbD, Wiggins & McTighe 2005). Understanding by Design uses a backward design in which a teacher/designer plans "backwards" from their goals. The focus is on teaching for understanding and transfer of these goals. They begin with creating three different types of goals: transfer, meaning making, and acquisition. The designer then aligns the assessments for the unit with these goals, and then designs the lessons and activities to address all of the goals. In the unit that will be discussed here, there is currently more of a focus on skills and knowledge (acquisition) rather than applying the content to real-world situations so that meaning making and transfer happens. The students also do not have a lot of opportunities to apply the 4 C's (critical thinking, communication, collaboration, and creativity), which are essential 21st Century skills. Student performance on the unit assessment is therefore weak, and they cannot apply the concepts in a different situation. There is also a lot of content in this unit, so in the past, it has taken longer than anticipated to cover in depth. It will be determined if there is anything that can be taught at the same time and with more meaning, or that can be taken out so as to save time but still cover all that needs to be taught.

Context Analysis

The context for this unit of study is a small, rural school in North Central Iowa. The school district has 3 schools: the elementary and high school are connected in one town, and the middle school is in another town 15 minutes away. There are about 150 students in the high school, and there are currently 2 sections of Algebra 1. In each section, there is a mix of freshmen through seniors. The freshmen are ones who took Pre-Algebra as 8th graders and are new to Algebra this year, while the seniors are ones who have taken this class before and have not been successful. The sophomores and juniors have either taken Algebra 1 and didn't pass, or were in Pre-Algebra or Extended Algebra as freshmen and sophomores. There is also

a mix of Caucasian and Hispanic students, and students who require special education services in each section.

The district's mission statement says the district will *"...provide a positive, supportive environment, offering a variety of challenging educational opportunities that will seek to produce responsible and productive citizens in an ever-changing world and to encourage life-long learning."* To meet this mission statement, and the board goals of "improving academic performance of all students" and "engaging and motivating students through instructional strategies that meet the needs of a 21st Century environment," the district has been focusing on AIW (Authentic Intellectual Work) in order to improve teachers' lessons. At the high school level, we are also looking to implement a Tiered Algebra curriculum, which would be an intervention program that we would use with struggling students in Algebra. The high school is also 1:1 PC laptops, but will be switching to 1:1 Chromebooks in the near future.

Rationale(s) for Using Understanding by Design

The purpose of this unit is not just for our students to learn how to write and graph equations of lines, or to improve standardized test scores, but also to improve the 21st Century skills of critical thinking, communication, creativity, and collaboration by creating engaging lessons that promote personal meaning making among the students and for them to apply these concepts to real-world situations. This, in fact, is the goal of Understanding by Design: acquire the knowledge and skills needed, make personal meaning with the content, and transfer that understanding to new situations. There are many real-life situations that can be modeled by linear equations and these models are used to predict future outcomes. In using Understanding by Design, students will be able to transfer their learning to create and use these equations and represent the information in different ways in order to influence an audience beyond school.

Learner Analysis

The learners for this unit are students in a high school Algebra 1 class. There are usually two sections of Algebra 1 with about 15-20 students in each section. There is typically a mix of freshmen through seniors (ages 14-18). The freshmen are ones who took Pre-Algebra as 8th graders and are new to Algebra this year, while the seniors are ones who have taken this class before and have not been successful. The sophomores and juniors have either taken Algebra 1 and didn't pass, or were in Pre-Algebra or Extended Algebra as freshmen and sophomores. There is also a mix of Caucasian and Hispanic students, and students who require special education services in each section.

Figure 1

Learner Analysis

Terms	**Data Sources & Collection**	**Summary of Characteristics** ***This data will be collected in the future as this unit is designed to be implemented next year.
Entry Behaviors	This will be the fourth unit in this class, so data will be collected from previous unit test scores, MAP/IA Assessment data, and a pre-assessment quiz for this unit.	
Prior knowledge	Data will be collected from the previous teacher (8th grade or pre-algebra) and a pre-assessment quiz will be given.	
Attitudes toward the content	A survey will be given to gauge students' attitudes toward the subject and the unit content. Observations from the	

	teacher in units prior to this one will also be used.	
General Learning Preference	A survey will be given at the beginning of the year to see how students learn best. Observations from the teacher in units prior to this one will also be used.	
Others, such as motivation,and learning ability	Observations from the teacher in units prior to this one will be used, as well as feedback from previous/current teachers and special education teachers if applicable.	
Overall impression		

Challenges and Resources for Teacher Learning

One challenge is how to set up the correct assessments to go with the content and what really needs to be assessed. Currently, there are a lot of drill and skill-based questions on the unit assessment, but this does not assess transfer and application of knowledge to a real-world situation. In order to turn this challenge into a possibility, it is important to make sure that the content standards, assessments, and lesson activities all align. With the help of a colleague or instructional coach, this can be kept on track.

Another challenge would be the lack of time for planning and teaching. This can be alleviated a bit by setting up planning sessions with the Instructional Coach during the school day. During this planning time, it is important to see if there is anything in the content that could be left out or combined with something else so that this unit does not take as long as it has in the past. Ideas can also come from from each AIW team, the Top of Iowa Conference math colleagues, and social media contacts to get ideas for lessons and how to combine

topics. The Instructional Coach can also keep the project on track with the backward design process, since the design tends to start with an activity or lesson, then see what standards it relates to, instead of going the other direction.

Overall Structure of Unit

The length of the unit is about 5-6 weeks. This would give a total of 25-30 class periods, each of which being 43 minutes in length.

Identify Desired Results: Stage 1

In the Understanding by Design process, it is important to identify the goals first in order to determine what should be assessed and what students should understand at the end of the unit. Three types of goals need to be addressed: transfer, meaning making, and acquisition of knowledge and skills. Acquisition goals refer to the skills (what students should be able to do) and knowledge (the facts and concepts students should gain from the teaching) that students should acquire throughout the unit. Meaning making goals are used so that the students can make the learning personal to them, and transfer goals are created so that students can use their learning in a different context. The reason for redesigning this unit is to address all three of these types of goals. Knowing the different forms of lines and creating equations given a set of information is not good enough. Students need to be able to use their learning in a real-life context.

Selection and Unpacking Established Goals/Standards

One standard that is addressed comes from the Iowa Core: Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. HSA.CED.A.2. Here is my **unpacked standard**.

Another standard that is addressed is also from the Iowa Core: Rearrange formulas to

highlight a quantity of interest, using the same reasoning as in solving equations. HSA.CED.A.4. Here is my **unpacked standard.**

Long-term transfer goals

As stated before, long-term transfer goals are used so that the teacher can help students use their learning in other contexts, whether that is in other classes, outside of school, or in the future, and are developed over time. Math teachers always hear the phrase, "When am I ever going to use this?" This question is taken out of the picture when teachers structure their units around these transfer goals. The content is posed in real-life situations so that students can clearly see how it will be used outside of the school setting. The other part of the long-term transfer goal is to have students apply their learning independently, without excessive help from the teacher. In real-life, there will not be someone there to guide students through a difficult problem. They will need to figure it out on their own, and these long-term transfer goals will help them to be more independent.

Figure 1:

Transfer Goals

Long-Term Transfer Goals	**Why (and When)These are Transfer Goals**
Students will be able to independently, wisely, and flexibly use their learning to create an equation in two or more variables that represents relationships between quantities.	There are many real-world situations that can be modeled by equations. The relationship between the quantities needs to be analyzed to determine which type of equation would be best suited for the information (linear, quadratic, etc), and then an accurate model can be created. The equation can then be graphed appropriately in order to gain more information.
Students will be able to independently, wisely and flexibly use their learning to solve a problem within that situation using the equation and graph to gain more information.	Equations and graphs aren't just used to look pretty. They represent real-world information and can be used to predict future events. For example, an equation is used to represent the speed of a car and its corresponding mile per gallon. We can then use the equation to determine how many miles per gallon the car would get if we were going 75 miles per hour, or vice versa.

Students will be able to independently, wisely, and flexibly use their learning to solve equations for a specified variable in order to highlight a quantity of interest and use that rearranged equation to gain new information about a real-life situation.	There are specific formulas used in real-life (i.e. the area formula for a rectangle: A=lw). However, we will not always in life know the length and width in order to calculate the area. Sometimes we will need to find what the length and the width need to be in order to get to a specific area. Rearranging this formula and others helps us to use the information we are given to find the other missing quantities. Students will be manipulating these equations in therms of a real-life situation.

Meaning-Making Goals

Meaning making goals are used so that the teacher can help students make connections to things that they already know so that they can personalize their learning. These goals help students make sense of what they are learning. To craft a meaning making goal, the designer needs to use words like analyze, explain, and interpret. Once the students can explain something in their own words, then they have a true understanding.

Big Ideas

A big idea is the overarching concept that we want students to understand by connecting facts, skills, and experiences. The big idea for this unit is the use of equations to describe numbers and relationships and model real-world phenomena.

Essential Questions

An essential question is a question about the subject that does not produce one, straightforward answer, but instead can lead to more questioning and produce many different answers and explanations. They allow students to dig deeper into the content, rather than produce answers based on facts or regurgitating information. The essential questions for this unit are:

- Why do we need equations?
- How can we use equations to model real-world relationships?

- How do we know what form of the equation would be best to use?
- How can I use my equation and graph to interpolate or extrapolate more information?
- Why do we need to rearrange equations/formulas?

Figure 2:

Desired Understanding Goals

Possible misunderstandings	Desired Understanding goals	Facet(s)
Students sometimes don't realize that we can use equations to model real-world phenomena. They think that they are just learning about equations because it's algebra class.	Students will understand that equations can be used to represent and model real-world relationships.	Application Self-knowledge
Without looking at the data or thinking carefully about the situation, students might think a situation can be modeled by a linear equation when it should be modeled with a quadratic equation, or vice versa. Students might think it would be easier to use point-slope form, for example, when slope-intercept form would be the best option to represent the situation.	Students will understand that the situation of the problem will affect the type of function that is used (linear, quadratic, etc.) and the form of equation that is used.	Explanation
Students might think that once they have the equation and the graph, then they are done. Students might think that an equation is useful on	Students will understand that the equation and resulting graph used to represent a situation can be used to predict future events regarding the relationship between the quantities, but that it may only be appropriate in representing the	Interpretation Explanation

the infinite interval, but sometimes that doesn't make sense (i.e. a line might be used to represent t-shirts sold and money made, but you can't sell a negative amount of t-shirts, so the equation/graph only works for positive values).	information on a specified interval.	
Students might not know where to plug in the known information in order to get new information, and therefore won't know which variable to solve for.	Students will understand that solving an equation for a specific variable helps us more easily find the solution to an unknown variable/quantity when another variable/quantity is known.	Application Explanation
Students might think that graphing an equation in point-slope form is easier, but rearranging it to be in slope-intercept form is just as easy and is easier to gain information from.	Students will understand that rearranging equations/formulas helps us to more easily graph an equation and use that graph to predict future events.	Application

Knowledge Acquisition Goals

Knowledge acquisition goals refer to the facts, definitions, and concepts that students should know as a result of teaching and learning. These goals are used in order to get a deeper understanding. A true understanding uses the facts, definitions, and concepts to infer a conclusion. In this unit:

Students will be able to define the relationship between two quantities.

Students will be able to define the unit vocabulary (slope, y-intercept, coordinates, slope-intercept form, point-slope form, standard form, regression line).

Students will be able to state why the equation would be better used in a new form.

Skill Acquisition Goals

Skill acquisition goals refer to the skills that students should be able to do as a result of teaching and learning. These skills are also used to promote a deeper understanding. There are many skills taught within a unit, but students need to know why a skill is important and when to use them to gain a deeper understanding of a concept. In this unit:

Students will be skillful at determining which quantity should go on which axis.

Students will be skillful at determining an appropriate scale for their graph.

Students will be skillful at plugging in known information in order to calculate new information.

Students will be skillful at finding slope given a graph or given two points.

Students will be skillful at creating equations in each form given two points or given a graph.

Relationship Among Three Goal Types

Acquisition goals, meaning making goals, and transfer goals are all connected in order to make understanding happen. Knowledge and skills are taught so that they can be used in meaning making and transfer. If one can make personal meaning from those knowledge and skills, it is much easier to use those skills in another situation (transfer). This can be compared to a show on television called “Worst Cooks in America.” When the contestants first come on the show, they have no idea how to cook, and are making horrible dishes. However, on the show, they are shown what each ingredient is and how to cut and measure them (acquisition). They then make personal meaning out of the dishes they are making by using foods that they and/or their families enjoy (meaning making). As they progress through the show, they learn what different flavors mix well together, and then are tasked with creating a new dish using different flavor combinations (transfer). With all of the information about ingredients, flavor combinations, and personalized learning, they can fully understand how certain foods complement each other and make new dishes using this information.

Determine Acceptable Evidence: Stage 2

Before deciding on what to do on vacation, it is first necessary to decide on what the point of the vacation is about. Is the point to relax? Is it to learn about ancient cultures? Then, based on the goal of the vacation, the destination can be decided. Finally, a plan can be developed for how to get there and all of the things to do while there to meet the goal for the trip. The same thing is true in the classroom. It is first necessary to determine the end goal in Stage 1(i.e. what is the purpose for the vacation?). Then, the assessments of those goals can be determined in Stage 2 (i.e. the destination of the vacation to meet that purpose). Finally, in Stage 3, the learning activities can be planned (i.e. the activities done while on the vacation). It is important to determine the evidence before creating the activities so it is known what needs to be taught, just like the destination needs to be determined before finding activities to do while there. In the end, everything gets tied back to the goals in Stage 1. Much like if the goal is to relax on vacation, the questions needs to be asked, "What place would be best to go to in order to do this?" the same needs to be done in the classroom. If the goal is for students to be able to problem-solve, for example, the question needs to be asked, "How can the degree to which students can problem solve be determined?" The evidence can then be created to determine student understanding before moving on to the activities we can do to get them there.

Performance Tasks

A performance task is a task in which a product is created or a performance is done to show one's knowledge/understanding and the transfer of their learning in a certain area. This is done often times using an authentic, real-world situation, and students have to use all of their knowledge together to create something in a new context. Based off of the essential questions and using the GRASPS (Goal, Role, Audience, Situation, Product/Performance, Standards) design to outline the tasks, the performance tasks for this unit are outlined below.

Performance Task 1

Goals:

- Your goal is to determine approximately how much Mrs. Tremmel and her husband should put their house up for sale for, based on square footage (not any other criteria).

Role:

- You are a personal realtor for Mrs. Tremmel and her husband.

Audience

- The target audience Mrs. Tremmel and her husband.

Situation:

- You have been asked to determine a base price that Mr. and Mrs. Tremmel should use in order to put their house up for sale based on information from around the area about a house's square footage and its sale price.

Products or Performance and Purpose:

- You will prepare a written proposal to Mr. and Mrs. Tremmel in which you include a graph and show mathematically how you calculated the price you think they should use to sell their house, based on their house's square footage. You should advise them that this is a base price and will also need to discuss other criteria that would influence pricing before they set a final price.

Standards and Criteria for Success See the rubric.

Performance Task 2

Goals:

- Your goal is to explain to the new realtor in your office which form (type of equation) of lines is best to use for the previous situation in order to give the customer the most information, and explain to him when the other forms would be useful.

Role:

- You are an experienced realtor who is training a new realtor the best way to present information to your clients.

Audience

- The target audience is the new realtor in the office.

Situation:

- The new realtor in your office isn't that experienced, and he is practicing his skills with the information that was used to give Mrs. Tremmel and her husband an estimate. He has created equations in all 3 forms to represent the information and graphed them all too (these will be shared with you). Since you are his trainer, you have been asked to evaluate his equations and solutions to make sure they are accurate, and explain to him which form is most efficient in this situation and gives the customer the most information. Then give a situation in which the other 2 forms would be more useful.

Products or Performance and Purpose:

- You will make a video recording of a conversation between you and the new realtor about the accuracy of the equations and what would need to be changed, if anything. You will also share which form you think is most efficient and gives the customer the most information for this situation, and provide examples of when the other 2 forms would be more appropriate. You will need to use sound, mathematical references to what each part of the equation means in your explanations so that the new realtor gets an idea of when each form would be appropriate to use depending on the information given and what the customer wants.

Standards and Criteria for Success See the rubric.

Figure 3

Assessment for Meaning Making Goal

Essential Questions and Understanding	Ideas for Possible Authentic Assessment Tasks/Products	Evaluative Criteria
Why do we need equations? Students will understand that equations can be used to represent and model real-world relationships.	**Student reflection and performance task 1**	**Clear, coherent** explanations are given, and explanation are justified **Accurate** equations, graphs, and explanations
How can we use equations to model real-world relationships?	**Student reflection and performance task 1**	**Appropriate** mathematical language used and examples given
How do we know what form of the equation would be best to use? Students will understand that the situation of the problem will affect the type of function that is used (linear, quadratic, etc.) and the form of equation that is used.	**Performance tasks 1 and 2**	**Effective** arguments given for which equation is used in each situation, and arguments are justified
How can I use my equation and graph to interpolate or extrapolate more	**Performance tasks 1 and 2**	

information? Students will understand that the equation and resulting graph used to represent a situation can be used to predict future events regarding the relationship between the quantities, but that it may only be appropriate in representing the information on a specified interval. **Why do we need to rearrange equations/formulas?** Students will understand that solving an equation for a specific variable helps us more easily find the solution to an unknown variable/quantity when another variable/quantity is known. Students will understand that rearranging equations/formulas helps us to more easily graph an equation and use that graph to predict future events.	**Performance tasks 1 and 2 and student reflection**	

Samples of Criteria for Meaning-Making Goals See rubric for student reflection and the rubrics above for the GRASPS tasks

Samples of Assessment for Knowledge and skill Acquisition

Various worksheets and in-class assignments/activites

Various exit tickets

Pre-assessment/Post-assessment using Google Form

Forms of a Line Quiz

Parallel and Perpendicular Lines and Regression Lines Quiz

Summarize Stage 2

Stage 2 is all about how to assess student understanding. This needs to come before the "lesson planning" and planning of learning activities in order to make sure we are assessing what really needs to be assessed (which comes from the goals established in Stage 1). All goals--transfer, understanding, and knowledge and acquisition--need to be addressed in our assessments. Transfer and understanding goals are addressed with an authentic situation--one where the students can apply their learning to a new, real-world context. Student reflection and self-assessment also comes into play here. However, the knowledge and acquisition goals can be assessed using what we think of as "normal" assessments via tests, quizzes, worksheets, etc. All of those assessments together will provide a good insight to the level of student understanding and the degree to which the goals from Stage 1 were met.

Plan Learning Experiences and Instruction: Stage 3

Stage 3 includes the "normal" day-to-day teaching and learning experiences that teachers are used to planning. Referring back to the vacation analogy from Stage 2, this stage involves the activities that will be done while on vacation. These activities should align with the goal of the vacation. For example, if the goal is to relax, then an appropriate activity would be to sit out on the beach. The same alignment needs to happen in the classroom. If the goal of the unit is for students to become better at problem-solving, then teaching and learning activities need to be planned that center around problem-solving strategies. The activities also need to align with the assessments--what needs to be assessed should be taught. These learning experiences need to be planned with consideration of sequencing, technology, and individualization.

Figure 4

WHERETO

W: Where are students headed? (Goal) Why are they headed there?	● Directly state the desired results (the transfer goals) and the essential questions from Stage 1 to the students at the beginning of the unit. ● Discuss why those goals and essential questions are important (Aside from learning these skills to use in later math classes, the knowledge you will gain in this unit will help you beyond school, especially if you need to track any type of data and determine what will happen in the future). ● Present the rubrics for the performance tasks. ● Pre-assess for content knowledge
H: How will you Hook the student? Create activities which are engaging	● Styrofoam cups stacking problem-how many cups will it take

	to make the stack taller than the teacher? (discussion on slope and slope-intercept form) ● Introduce performance tasks
E:Experiences students will have; What key ideas will students Explore?	● Initial cup stacking activity starts the discussion on slope and slope-intercept form ● Slope and standard form discovery activities ● Desmos online simulations for graphing in the three forms ● Graphic organizers to compare the three types of lines ● Using Desmos online graphing calculator to graph data and lines ● Research how lines and equations of lines are used in real-life and create discussion posts on Google Classroom about what they found
R: Reflect and Rethink; How will students Revise and Refine?	● Scaffolded practice and cooperative group work ● Student self-assessments (checklist) ● Corrections on assignments and quizzes
E: Exhibit student work; How will students self-Evaluate	● Scaffolded practice and cooperative group work ● K-W-L charts and reflection logs/self-assessments as described above ● Exit tickets--one minute essay summarizing main points and identify questions they have yet ● Fill out reflection sheet before making corrections on assignments and quizzes
T: Tailor and Personalize- How might the teacher appeal to a greater variety of learning styles by maximizing student options?	● Present information/activities/assignments in different contexts--business, farming, interests they have now ● Present information/activities in different ways--lecture/notes,

	hands-on activities, discovery activities, flipped-instruction ● Create cooperative learning groups based on level of understanding (a "low" student with a "mid-high" and a "high" with a "mid-low") ● Differentiated station work depending on level of understanding ● Provide guided notes and organizers ● Student-led discussions about how lines and equations of lines are used in everyday life
O: How will the lessons be <u>organized</u> for maximum <u>engagement</u>?	● "Hook" activity--cups stacking ● Pre-assessment ● Present goals and essential questions along with the rubrics for the performance task ● Learn about slope (provide real-world contexts within these lessons) ● Learn about the three forms (provide real-world contexts within these lessons) ● Organize thoughts about all three forms ● Learn about scatter plots and trend lines ● Practice ● Performance tasks

With the "hook" activity, students will be discovering some of the content on their own and a follow up discussion will take place about slope and how they can write their answers to this problem as an equation, then discuss what each part of the equation represents. The performance task will also be introduced to the students as an assessment to achieve the transfer goal. As the students go through the unit, the teacher will have to make decisions about when to use other activities like this where discovery is the main form of learning, or whether direct instruction or another approach would be best. These decisions will be based on the content and the individual learners. Formative assessments along with

student-self assessments will be given throughout to determine if more help is needed and what teaching approach is best to use to reteach a concept. As students move through the unit, meaning-making and transfer should begin to be demonstrated. They can then apply their knowledge in a new, authentic situation with the performance tasks.

Figure 5

Teaching Approaches and components

Terms of Teaching Approaches/Components	**Explanation of the teaching approaches/components that include**	**Rationales for pedagogically using digital technologies**
Transfer This goal seeks to support the learners' ability to *transfer* their learning autonomously and effectively in new situations	● Project-based learning (performance tasks)	Using technology (Desmos online graphing calculator) for the scatter plots and trend lines activity and the performance tasks allows students to check their work that they did by hand. It also gives a more accurate representation of the data and equation.
Meaning This goal seeks to help students *construct* meaning (.i.e., come to an understanding) of important ideas and processes.	● Problem-based learning (cups stacking activity, scatter plots and trend lines activity) ● Discovery-based learning (slope activity, standard form activity) ● Hands-on learning (slope activity and Desmos activity to graph in all 3 forms) ● Graphic organizers ● Student reflections/self-assessment	Using technology allows students to be able to manipulate the lines in a way that can't be done on paper. They can drag one point, or change one number in the equation and immediately see what it does to the graph and the rest of the equation. They will also use Google Classroom to write discussion posts about how lines and equations of lines are used in real-life. Using Google Classroom will provide a way for the conversation to continue

	• Student-led discussions (how lines and equations of lines are used in real-life)	throughout the unit, and not just be a one day thing.
Acquisition This goal seeks to help learners *aquire* factural infomraiton and basic skills.	• Direct Instruction/Flipped-instruction • Drill and practice • Cooperative Learning	Using technology allows for learners to interact with the content in a different way. They can watch an instructional video at home, then work on the "homework" during class time where the teacher can provide necessary feedback. They can also do drill and practice problems in a fun way with online games like Kahoot.

Figure 6

Major Learning Events and Instruction

Acquire targeted knowledge and skills	Direct instruction and drill and practice on each form of a line and converting among forms
	Kahoot games for slope and writing equations in each form
	Cooperative learning groups for practicing graphing and writing equations in each form
Make meaning of important ideas	Cups stacking activity
	Slope discovery activty
	Standard form discovery activity
	Graphic organizer to organize thoughts about all three forms of a line
	Student assessments (K-W-L charts, reflection logs/self-assessments as described above, exit tickets describing main points and identifying questions they have yet)
	Scatter plots and trend lines activity

	Student discussions on Google Classroom about how lines and equations of lines are used in real-life
Transfer their learning to new situations	Project-based learning by engaging the students in the performance task.

Figure 7

Beginning and Ending Lessons

Beginning Lessons in the Unit	Ending Lesson in the Unit
Intro activity-cups stacking activity to gets students "hooked" and introduce slope and slope-intercept form	Share their performance tasks with each other and with others outside of the classroom (make a video about their project and presentation to share online)

Selecting Existing Teaching Materials

- Desmos online activity to help students develop their proficiency and understanding of graphing lines in all three forms.
- Youtube videos about standard form and converting between forms for flipped instruction.
- Slope discovery activity (activity not provided here due to copyright)

Creating Your own Teaching Materials

- Teacher created video of writing equations of lines in all three forms given two points for flipped instruction.
- Graphic Organizer to organize thoughts on the three different forms of a line
- Student self-assessment checklist

Differentiate Instruction to Tailor the Needs of Different Learners

- Present information/activities/assignments in different contexts--business, farming, interests they have now
- Present information/activities in different ways--lecture/notes, hands-on activities, discovery activities, flipped-instruction

- Create cooperative learning groups based on level of understanding (a “low” student with a “mid-high” and a “high” with a “mid-low”)
- Differentiated station work depending on level of understanding
- Provide guided notes and organizers
- Student-led discussions about how lines and equations of lines are used in everyday life

Summarization of Stage 3

The learning activities in Stage 3 need to focus on the experiences that students will need in order to meet the goals outlined in Stage 1. This stage is the area that most teachers are familiar with, but again, the activities need to align with the unit goals and the assessments, not necessarily with what the teacher is most comfortable doing. Careful consideration of all goals (transfer, meaning making, and acquisition) as well as how the lessons will be organized and individualized to meet all students’ needs should to go into the planning of these learning experiences. Once students go through these learning experiences, they should be ready to demonstrate their mastery of the transfer and meaning making goals in the performance tasks.

Refine Design (Stages 4, 5 & 6)

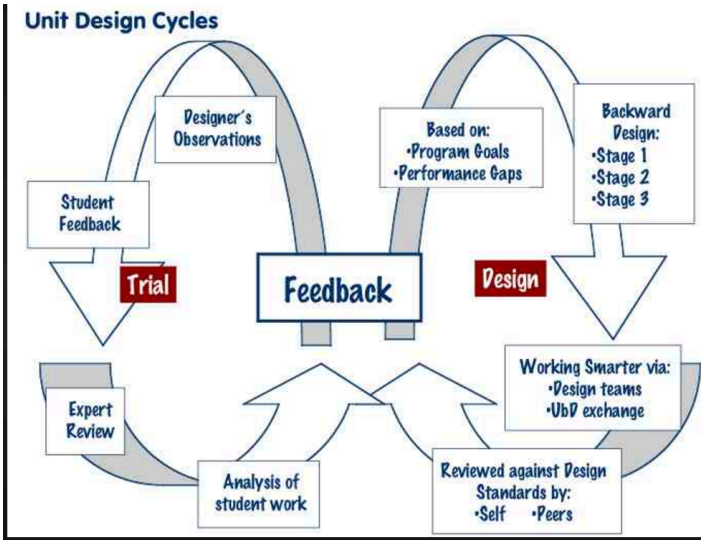
Refining Design

Unit planning with UbD is an ongoing process. It involves constant reflection and evaluation from the unit designer along with peers, experts, and students. During the design phase, the designer and peers can look for criteria such as proper goals, assessments, and alignment using the UbD standards. During the implementation phase, unit designers can get feedback from the teacher as to what is working and what is not, as well as observations from other colleagues and administrators. This feedback is based on observable “look-fors” during

implementation. Evaluation does not stop there, though. It continues even after the unit is complete. Feedback then comes from looking at the results from the performance tasks, and getting input from observers and students for what they liked, didn't like, and what could be improved about the unit. The design is tweaked throughout the design, implementation, and completion phases based on the observations and feedback of the designer and others.

https://pixabay.com/en/arrows-district-evaluation-1262403/

Unit Design Cycle



Unit Design and Feedback Loop

The Unit Design and Feedback Loop above describes the process involved in refining the unit design. First is the design phase where the designer decides on a unit to create or change based on certain program goals that need to be met or gaps in student achievement that have been observed. The backward design process is then followed to set the goals (transfer, meaning-making, and acquisition) in Stage 1, create the assessments that will provide acceptable evidence of student learning to meet those goals in Stage 2, and design the learning experiences that students will have in order to get them ready for the summative assessment in Stage 3. Throughout the design process and the when it has all been written, the designer uses the UbD design standards to determine if the goals are acceptable, the assessment is valid, the learning experiences are meaningful and engaging, and that all three are aligned properly in Stage 4. After self-assessing the unit, the design is then reviewed by peers and experts against the same standards. Adjustments are made based on the feedback from each part and then the design is ready to be implemented.

Feedback is also given during the implementation phase in Stage 5. This feedback comes from the designer's observations, as well as peer and other administrator's observations. These are based on a set of "look-fors" already defined. Feedback in this stage also comes from the formative assessments that the teacher gives and informal feedback from the students. The results of these formative assessments and observations will provide the evidence for any adjustments that need to be made to the design.

Once the unit is complete, student achievement of the goals is assessed from the summative assessment. Feedback is also sought from the students about what they liked, didn't like, and what could be changed. The results of the final assessment and the feedback from students provides evidence needed to make any final adjustments to the design in Stage 6. The unit can then be implemented again the next year and feedback can be done again in the same way to determine if more adjustments are needed.

Self-Assessment: UbD Feedback Matrix

Self-Assessment can be done during and after the drafting phase of the unit design

process. Once the unit is written it is easier to go back over it and see the unit as a whole and identify any mistakes that need to be fixed or adjustments that need to be made. The "UbD Design Standards 2.0" (Figure 7) can aid in the self-assessment process.

Figure 6

UbD Feedback Matrix

Stage	Feedback Source	Drafting	Implementation	Results
4	Self-Assessment	**X**		
4	Peer/Expert Review	**X**		
4	Expert Review	**X**		
5	Designer's Observation		**X**	
5	Formative Assessments		**X**	
5	Outside Observers		**X**	
6	Analysis of Results			**X**
6	Students		**X**	**X**

Peer/Expert Review

Peer and expert review is also important during the design phase. It is sometimes difficult to see our own mistakes and the weaknesses of the design, so peers and other experts can assist in identifying these and help to improve the unit design. The peer review process should follow the "Peer Review Protocol" outlined in "The Understanding by Design Guide

to Advanced Concepts in Creating and Reviewing Units" (pg. 122). They can also use the "UbD Design Standards 2.0" (Figure 7) to aid in the review process as well.

Figure 7:

UbD Design Standards 2.0

The UbD Design Standards provide a way to review a UbD unit in a uniform way. It helps to identify the strengths and weaknesses of a unit, and helps to make sure that the unit is aligned among all three stages. As mentioned before, this rubric can be used for self-assessment, as well as peer and expert review.

Self-Review of the "Using Equations to Model Real-World Situations" unit

3 = Meets the standard 2 = Partially meets the standard
1 = Does not yet meet the standard

Unit Plan Stage 1	3	2	1	Feedback and Guidance
1. Specifies the desired long-term transfer goals that involve genuine accomplishment.	X			
2. Identifies important, transferable ideas worth exploring and understanding.	X			
3. Identifies understandings stated as full-sentence generalizations: Students will understand that . . .	X			
4. Is framed by a few open-ended, thought-provoking, and focusing essential questions.		X		
5. Identifies relevant standards, mission, or program goals, to be addressed in all three stages.	X			
6. Identifies knowledge and skill needed to achieve understanding and address the established goals.	X			
7. Aligns all the elements so that Stage 1 is focused and coherent.		X		

Stage 2				
8. Specifies valid assessment evidence of all desired results: Stage 2 aligns with Stage 1.		**X**		
9. Includes authentic performance tasks based on one or more facets of understanding.	**X**			
10. Provides sufficient opportunities for students to reveal their achievement.	**X**			
11. Includes evaluative criteria to align each task to desired results and to provide suitable feedback on performance.	**X**			
Stage 3				
12. Includes learning events and instruction needed to help learners. **a. Acquire targeted knowledge and skills.** **b. Make meaning of important ideas.** **c. Transfer their learning to new situations.**	**X**			
13. Effectively incorporates the WHERETO elements so that the unit is likely to be engaging and effective for all learners.	**X**			
Overall				
14. Is coherent, with all three stages in alignment.		**X**		
15. Is likely to work; is feasible and appropriate for this situation.	**X**			

Peer-Review of the "Using Equations to Model Real-World Situations" unit

Unit Plan Stage 1	3	2	1	Feedback and Guidance
1. Specifies the desired long-term transfer goals that involve genuine accomplishment.	X			
2. Identifies important, transferable ideas worth exploring and understanding.	X			
3. Identifies understandings stated as full-sentence generalizations: Students will understand that . . .	X			
4. Is framed by a few open-ended, thought-provoking, and focusing essential questions.	X			
5. Identifies relevant standards, mission, or program goals, to be addressed in all three stages.	X			
6. Identifies knowledge and skill needed to achieve understanding and address the established goals.	X			
7. Aligns all the elements so that Stage 1 is focused and coherent.	X			
Stage 2				
8. Specifies valid assessment evidence of all desired results: Stage 2 aligns with Stage 1.	X			
9. Includes authentic performance tasks based on one or more facets of understanding.	X			
10. Provides sufficient opportunities for students to reveal their achievement.	X			
11. Includes evaluative criteria to align each task to	X			

desired results and to provide suitable feedback on performance.				
Stage 3				
12. Includes learning events and instruction needed to help learners. **a. Acquire targeted knowledge and skills.** **b. Make meaning of important ideas.** **c. Transfer their learning to new situations.**	**X**			
13. Effectively incorporates the WHERETO elements so that the unit is likely to be engaging and effective for all learners.	**X**			
Overall				
14. Is coherent, with all three stages in alignment.	**X**			
15. Is likely to work; is feasible and appropriate for this situation.	**X**			

Observation by the Designer during Implementation-Stage 5

During implementation, it is important for the designer to see his/her design in action. Sometimes, what seems good on paper does not actually turn out very well when it is done, so this provides an opportunity for the designer to make sure what is written will actually work. One way this could be done would be to keep a reflective journal to detail the events of each class period in which the unit is implemented each day. The designer could also add comments, suggestions, and other notes to the UbD unit document itself to help remember what needed to be changed or adjusted, or even edit the document right away. Some questions to consider during these observations and reflections come from “The

Understanding by Design Guide to Advanced Concepts in Creating and Reviewing Units" (pg. 125):

- Which parts of the unit are working well? Which aren't?
- When are students most purposefully engaged? When aren't they? Why?
- Do certain elements of the unit (such as essential questions, performance tasks) work better with some students than others? Why might that be?
- Does the time frame work as planned?
- Are the directions for tasks and activities clear to learners?
- What do the ongoing (formative) assessments reveal about revisions needed for the future?
- What adjustments will you make the next time?

Observation by outsiders

Observations by others not involved in the unit creating process allow for a different perspective on the unit implementation. Each observer offers a different viewpoint and can critique the unit in a different way. These outside perspectives can come from administrators, an instructional coach, or other teachers who would be implementing this unit in the future. These teachers would be a great way to get feedback on how different parts of the unit could be changed to meet different learners needs, and discuss other activities that could be used to help students meet the transfer and meaning-making goals. Each teacher could reflect on what they see each day/week and have weekly meetings to discuss their findings.

The instructional coach would be a great resource as well to help determine if the standards and goals that were outlined in Stage 1 are really being met by the students. He/She could be part of the conversation at the beginning of the unit with the students about the goals and essential questions, and observe the classroom and help the teacher analyze the data from the formative assessments throughout the unit to determine if another teaching method is needed and if something in the design needs to be changed.

The observations made by these outsiders are based on a set of observable "look fors" so that the outsiders have something to guide them in their observations and they are able to

provide sufficient feedback. These can be changed to fit the situation, but an example from "The Understanding by Design Guide to Advanced Concepts in Creating and Reviewing Units" (pg. 126) is shown below.

Rate the following indicators on the scale of 1= not at all; 2 = infrequently; 3= somewhat; or 4 = greatly.

To what extent are

1. Instruction and assessment focused on big ideas and essential questions based on established standards or outcomes? _____
2. Essential questions revisited throughout a unit? _____
3. Pre-assessments used to check students' prior knowledge and potential misconceptions regarding new topics of study? _____
4. Opening hooks used to engage students in exploring the big ideas and essential questions? _____
5. Students' understanding of the big ideas and core processes assessed through authentic tasks involving one or more of the six facets? _____
6. Evaluations of student products/performances based upon known criteria/rubrics, performance standards, and models (exemplars)? _____
7. Appropriate instructional strategies used to help learners *transfer* their learning, *make meaning* of the big ideas, and *acquire* knowledge and skills? _____
8. Students given regular opportunities to rethink, revise, and reflect on their work based on feedback from ongoing (formative) assessments? _____
9. The students expected to self-assess or reflect on their work and learning and set goals for improvement? _____
10. Other: _____

_____. _____

Feedback from Results-Stage 6

In order to determine if the unit was successful in its design, the results need to be analyzed to determine the extent to which the desired results from Stage 1 were achieved. Looking at the results also helps to determine the effectiveness of the learning experiences and the where students struggled the most or had the most success. The "Final Self-Assessment Form" below can be used to help determine the overall strengths and weaknesses of the design.

Final Self-assessment Form

Figure 6

UbD Stage 6: Final Unit Assessment Form Unit

Unit Overall unit effectiveness: ineffective | somewhat effective | effective Percent for whom effective: a few | a minority | a majority | all Overall unit engagement: a few | a minority | a majority | all
UNIT STRENGTHS: Check and briefly note any relevant observation: … Students were most successful at … Students were most engaged when … The Stage 1 elements best achieved were … Evidence showed unusually strong results at … Even my less able students
UNIT WEAKNESSES: Check and briefly note any relevant observation: … The unit was not as effective as it might have been, as shown by … Students were least successful at … Students were least engaged when … Stage 1 elements targeted that were not achieved were … Evidence showed disappointing results at … My less able students had trouble with

Reviewing Student work in PLC Teams

Evaluating student work in PLC teams provides additional pairs of eyes looking at the data and interpreting what it means. The data then provides a means to make improvement in

the plan and in instruction. PLC teams should meet at least once per week to discuss the data and look for patterns in student performance. They can use these patterns to determine areas of strength and weakness in the design. PLC teams can use the following questions as a guide when analyzing student achievement:

Evaluate:

- What understanding and transfer goals are being assessed?
- What knowledge and skills are being assessed?
- What kinds of thinking are required (e.g., interpretation, problem solving, evaluation)?
- What kinds of technology are required (e.g. word processing, web 2.0 tools, software)?
- Are these the results I (we) expected? Why or why not?

Given established criteria/rubric(s):

- In what subject task did the student(s) perform best?
- What weaknesses are evident?
- What misconceptions are revealed?

Interpret

- What does this work reveal about student understanding and performance?
- What patterns are evident?
- Are these results consistent with other achievement data?
- What questions does this work raise?
- Are there any surprises? Any anomalies?
- Is there evidence of improvement or decline? If so, what caused the changes?
- Are there different possible explanations for these results?

Feedback from Students

Getting feedback from students is a great way to identify any strengths and weaknesses of the design. The students are the ones who are going through it and using it, and they know what was beneficial to them and what did not turn out so well. Feedback from the students can be done formally using a Google form survey or some other written response from the students, or informally by having a conversation and documenting their responses. In either case, some questions for them to respond to to help decide what needs to be changed or what went well are:

- Which parts of the unit best supported your learning? Why?
- Which parts of the unit didn't help your learning? Why?
- Which parts of the unit were most interesting to you?
- Which parts of the unit were least interesting to you?
- What was needlessly frustrating? How might it be improved?
- What do you now really understand as a result of this unit?
- To what extent was the purpose and value of the work clear to you?
- What was surprising? Unexpected?
- What changes would you recommend for the next time this unit is taught?

Summarize Alignment Checking

When developing a unit using the Understanding by Design process, it is important for the unit designer to check alignment throughout the development process, during implementation, and after implementation. The Stage 1 goals need to be used to develop the assessments in Stage 2, and the Stage 3 activities need to be aligned to what is being assessed in Stage 2. The designer needs to check throughout the design process to make sure that what is needed to be assessed is being taught in the learning activities from Stage 3, and that all of the learning activities and assessments are aligned back to the standards and goals from Stage 1. In Stage 4, the designer has the opportunity to step back and reflect on the entire unit to see if all is aligned properly. The peer review can help with this process as well. During implementation, the designer has another opportunity to see if the learning activities and

assessments align with the goals (Stage 5), and in Stage 6, the designer can use the results from the assessment as another way to see if what was being taught and assessed matches with the intended goals. Checking for alignment in these different ways provides different perspectives to help make sure that the students are able to meet the goals as desired.

Conclusion

The overall goal of Understanding by Design is for students to be able to flexibly, wiseley, and independently transfer their learning to a new, authentic situation. By going through the backward design process, the unit described in this plan allows for that transfer. First, three types of goals were created (transfer, meaning-making, and acquisition) as well as essential questions that need to be considered for the unit. These goals are the basis for the rest of the stages. In Stage 2, assessments were created for each type of goal. The transfer goals are assessed with a performance assessment in which students use their learning in a new, real-world situation. The learning activities are then planned in Stage 3 to ensure that students will have the knowledge, skills, and personal meaning to be successful in meeting the goals that are being assessed. In Stages 4, 5, and 6, the designer is given feedback through self-reflection, peer review, observations, student feedback, and the results of the summative assessment. The designer uses that feedback to fix any alignment issues or change any of the goals, assessments, or learning activities.

UbD is an ongoing process and reflection is necessary throughout the design process in order to ensure that students are meeting the goals as desired. The process takes time, and gets messy at times, but in the end, it is what is best for the students. The goal of school is not to just "learn and purge" for the test. Students need to be able to make personal meaning of what they are learning and be able to use it in other contexts (in other units, classes, and outside of school). Going through the Understanding by Design process allows students achieve this by helping them to better understand why they are learning the content and how it can be used outside of a classroom setting.