



New Fellow Education Transfer Plan

Title of ETP	Learning to Learn
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Sponsor Company	United Defense Limited Partners, Ground Systems Division (UDLP GSD)
Name of Mentor	Ann Hennon
National Board Certificate Area	Mathematics 9-12
<p>I, the IISME Fellow named above, affirm that the ETP I am submitting is my own work, that I acknowledged sources where appropriate, and that I avoided including any proprietary information of the Sponsor Company. By my submission I am assigning to IISME my entire copyright in the ETP. I understand IISME is simultaneously granting me a license to use the ETP for pedagogical purposes.</p>	
<hr style="width: 40%; margin: 0 auto;"/> Signature	<hr style="width: 40%; margin: 0 auto;"/> Date

Category	<p>Curriculum</p> <p>Subject: <u>Math</u> Science Technology _____</p> <p>Level: Elem Middle <u>High</u> Other</p> <p>Staff Development</p> <p><i>Describe</i> _____</p>
Objectives	<p>Students will be able to learn about their own learning in order to improve their academic successes</p> <p>→ National Board Standard VI: Assessment</p>
Abstract (50 words or less)	<p>This ETP will capture a series of techniques that teachers can use to help their students understand their own learning so that they can take this knowledge and apply it to learn smarter, not harder. The package will include project-based learning, KWL and other concept mapping charts, peer reviews, and self reflection pieces. Each of these will be created to approach the learning process from a slightly different standpoint.</p>
Describe how your ETP aligns with the National Board Standard stated in your proposal.	<p>The main purpose of this ETP is to give students the tools they need to assess their own learning, which is a direct outcome of NBC VI: Assessment.</p>

Describe the connection between your ETP and the Summer Fellowship.	I currently work at United Defense (http://www.uniteddefense.com) in Santa Clara, a government contractor that builds and designs armored vehicles, commonly but inaccurately referred to as tanks. This company supports multi-billion dollar contracts to design smarter, more efficient machines and the systems that run these machines. In order to retain these high-profile contracts, the company has developed an extremely elaborate system of checks and balances on every process that they perform, from the very small to the very large. The concept of checks and balances at my company closely parallels an educational philosophy to create independent thinkers who are productive members of society. One major way to nurture independent thinking is to help students develop metacognitive skills; this includes analyzing their own learning and then taking this information and applying it to the next learning opportunity. My ETP will focus on techniques that teachers can use to help foster metacognitive awareness and development in their students.
Resources Needed	<ul style="list-style-type: none"> • Digital Projector • > 3 Ti-84+ graphing calculators • CBR with motion sensor
Evaluation/Assessment Measures Used	Since my ETP focuses on assessment for the purpose of improving metacognition, the assessment and evaluations are intertwined in the ETP's description.
Formatting specifications	PC <u> X </u> or Mac <u> </u> Software used <u> Microsoft Word 2002 </u>
Submitted Copy	Soft and hard copy due to peer coach by the end of the summer fellowship. Also, a copy of the cover sheet signed by a school site administrator submitted to IISME Oct.3, 2004 to receive \$300 grant.
<p>I, the Mentor named above [please select one of the following],</p> <ul style="list-style-type: none"> <input type="checkbox"/> have read the attached ETP, and my comments, if any, appear below. <input type="checkbox"/> have read the attached ETP, and, as outlined in the IISME-Company Fellowship Agreement, have reviewed it on behalf of the Sponsor Company, and have determined that the ETP does not contain any Sponsor-proprietary information. My additional comments, if any, appear below. <p>Comments:</p> <p>_____</p> <p>Signature _____ Date</p>	
<p>Administrator's comments:</p> <p>_____</p> <p>Signature _____ Date</p>	

Learning to Learn

Premise: As a new teacher, I have hopes and aspirations to know what all of my students are thinking and comprehending as I teach them so I may become a more effective educator. This past year I have developed a teacher-centered approach to assessing student learning as part of a Master's in Education from the University of California, at Davis. In my thesis (located at <http://www.mrjohns.net/masters/thesis.pdf>), I outlined a process whereby a teacher could implement a series of mini daily and weekly quizzes that were used to inform students about their progress on a continual basis. The results varied from student to student, and the average improvement per student in my case group was 8%. This was a promising finding to me, to know that I could devise, implement, and analyze a system to improve my student's understanding of the course curriculum. However, after the final analysis had been made, I had devoted far too much time in maintaining these records for future analysis. Not only that, but the learning was teacher-centered, which put the "burden" of teaching largely on my shoulders. Now in my second year of teaching, I am looking for ways to continue an increased level of learning, but to use a different means to accomplish the same ends, that was largely student and project-centered. Herein lie the chronicles of my quest.

If a student could understand the process of their own learning, it would stand to reason that they would not only improve their understanding, but also improve their confidence in the subject material. The techniques outlined here will have a mathematics flavor to them, but can be applied to a variety of content areas of any grade level.

There are several modifications to a normal curriculum that can benefit students by helping them become more self-aware. The outline below will guide you through the various aspects of the new assessment process for any mathematics curriculum, and can be implemented to a variety of other disciplines.

The assessment process timeline

Appendices include examples of:

1. Concept mapping
2. Goal-setting
3. Project-based learning
 - a. Hiker (linear)
 - b. Car Collision (linear)
 - c. Spinning Squares (quadratic)
 - d. Ball Bounce (exponentials)
 - e. Rumors (logistics)
 - f. Light Bounce (trigonometry)
 - g. Pendulum (sinusoids)

Resource: Overview of Metacognition Through Student-Centered Learning Pedagogy

North Central Regional Educational Laboratory

<http://www.ncrel.org/sdrs/areas/issues/students/learning/lr200.htm>

The Assessment Process

The purpose of assessment is two fold: the perspective of the teacher, and the perspective of the student. The latter is the more widely neglected by educators than the former. This enables students the ability to create their own goals and see whether or not they have reached them, something I was never taught in school and wish that I had been. While parts of this document modify what the teacher typically is assessing, the remainder will focus on students assessing each other and themselves. The timeline below is for use in any assignment, especially for project-based assignments that are given in the appendix.

Day 1

1. Students will be given the rubric for the assignment before the assignment begins. As a class, the rubric is discussed and clarified
2. The teacher will place the students into groups of 4 and show them how to brainstorm a game plan for accomplishing each aspect of the rubric's categories
3. Once completed, the groups will write down the leaves of the brainstorming, which will represent the individual tasks needed in order to complete the assignment
4. The groups will place the tasks in a logical order to accomplish
5. As a class bring together all main points from each group into a common set of tasks
6. In each group, divvy out the responsibilities
7. As part of goal-setting, each student will write down their goals and the dates they expect to complete them. Having written goals helps reinforce their importance and value.

Checkpoint 1 (1/3 of the way to end date)*

1. Students will come back in their groups to look at their checklists once again. How much have they completed that they said they would?
2. Students compute percentage completed individually and as a group.
3. Teacher recognizes students who have completed the most of their goals percentage wise, and those who are ahead of schedule
4. Students use their rubrics to grade each other's work so far. 3 rubrics should be completed for each person and attached to the final submission, and at least 3 comments made (2 positive, 1 suggestion)
5. Individually, these students write what their successes and pitfalls have been so far in the assignment.
6. As a class, students write 2 lists: Pitfalls and Successes (encouraging participation from students from step 3)
7. Teacher emphasizes to those who are behind that in order to succeed that they need to follow the steps outlined by the class.
8. Students update the timelines to complete each of their tasks.
9. If there's time, students work on the next phase of their assignment, or revise their work depending upon the scores they received by their peers on the rubric.

Checkpoint 2 (2/3 of the way to end date)*

1. Same as the steps for checkpoint 1.
2. In addition, students have 2 percentage completed numbers now. Has this percentage improve, stayed the same, or decreased? Have students write a paragraph to explain their progress so far based on these numbers. Has this process motivated them more, or less?

Checkpoint 3 (1 day before end date)

1. Same as the steps for checkpoint 1.
2. Students write a reflection on this process. What worked well for them? Conversely, what didn't work as well?

Last Day

1. Presentation of findings (report, poster, overhead, projector, etc)
2. Group evaluation of each other and as a whole.

Assessment

1. 9 rubrics per assignment + group evaluation averaged
2. Final reflection

3. Presentation
4. Assignment Completion

* depending on time, this could be collapsed into 1 checkpoint, but this will be less effective and not hit as much home in the student's minds to have the decreased amount of feedback.

Appendix A Concept mapping

Concept Maps

Resource: http://www.coun.uvic.ca/learn/program/hndouts/map_ho.html

Brief introduction to what concept mapping enables you to do.

Resource: <http://www.inspiration.com/home.cfm>

Software you can use to create concept maps and other visual aids. Free demo version.

Resource: <http://www.mindjet.com/us/>

Software you can use to create concept maps. Free demo version.

Resource: <http://www.smarttech.com/products/smartideas/index.asp>

Software you can use to create concept maps. Free demo version.

KWL and KWHL charts

Resource: <http://curry.edschool.virginia.edu/go/readquest/strat/kwl.html>

The purpose of KWL is to have students link prior knowledge to new situations and to make new connections. By making connections to what they are studying, the teacher has a sense of what misconceptions students are having. In addition, students have the ability to see if they can answer the questions they originally had after the lesson has been presented. This site has a brief introduction.

Resource: <http://www.ncsu.edu/midlink/KWL.chart.html>

This site has pdf's available of KWL and KWHL worksheets for quick printing.

Frayer Model

Resource: <http://www.justreadnow.com/strategies/frayer.htm>

This method allows students to make connections to a new idea and what they already know, citing examples illustrating the idea in question.

Resource: <http://homepage.mac.com/johnevers/Media/What%20is%20the%20Framer.pdf>

How to use the Frayer Model, with an example in a mathematics classroom.

Worksheet:



Appendix B
Goal Setting

“If you want to lead a happy life, tie it to a goal, not to people or things”

-- Albert Einstein

The smartest student in your classroom could be the most unsuccessful if he is not properly motivated to perform.

Motivational Introduction

http://www.ndt-ed.org/TeachingResources/ClassroomTips/Goal_Setting.htm

Interactive Tutorial for Students

<http://www.trainingpost.org/gsover.htm>

Goal-Setting by Creating a Portfolio

<http://www.schools.pinellas.k12.fl.us/educators/portfolio.asp>

The Common Motivational Cold

College Board

<http://www.collegeboard.com/article/0,3868,2-8-0-8454,00.html>

Activity for Introducing Goal Setting

<http://www.etr.org/recapp/freebies/W4SGoalSetting200212.pdf>



Appendix C

Project-based learning

Here are few examples of rubrics you may have seen or even used in your classroom, with suggested modifications. Afterwards I have provided 7 project-based assignments about mathematics topics along with rubrics that reflect the concepts outlined in this document.

I hope to integrate a writing thread into my mathematics curriculum this upcoming year. Here's a potential rubric for writing how math was involved in some major technological advancement in the last 100 years.

Assessment for writing a research paper		%
Neatness		5
Grammar		10
Punctuation		10
Paragraphs	5 sentences apiece	10
	Intro paragraph	10
	3 supporting paragraphs	10
	Conclusion paragraph	10
Content/Accuracy		35
	Total	100

Analysis

This is a very mechanical rubric because it assesses how a student can identify, process and discuss a topic they researched. However, little to no reward is given to the thought processes needed by the student to decide how to research, how to decide if the research is valid, and how to design the presentation of the collected information. Here's a modified rubric for the same paper, but capturing these assessment perspectives:

Assessment for writing a research paper		%
Research Outline		20
Research Validity	Paragraph describing why you picked these research sources and not others	10
Presentation	5 paragraph structure	20
	Grammar/punctuation	5
Content Accuracy		25
Participation in Peer Review	Review 2 other papers and attach comments to final draft	10
Reflection	Paragraph describing what I learned from this process	10
	Total	100

The assessment's purpose has now taken a huge shift towards the learning process. The process needed in order to create a thought-provoking paper based upon research of a topic is highly-overlooked in current education practices. A considerable amount of work needed to make a successful paper, or a proposal in the workforce, is based upon the research used to create it. And not only securing the information is enough; valid data must be collected before a report can be created than contains any credibility itself. The business sector belief that the report and its presenter are only as the credible as the data they use motivated the absolute necessity to have students thinking about this at a younger age so that they will inherently bring credibility to whatever job they decide to take.

Analysis

Participating in peer reviews is also another important skill to have. It is very commonplace for work to be double, triple, and quadruple checked in business projects and products before they are finally presented to their target audience. Developing the ability to critique others constructively and to take constructive criticism will be a valuable and marketable job skill.

Reflections are the key to freeing a person’s mind from mindless rote memorization and taking a step towards self-awareness and evaluation. Giving students this tool will enable them to more consistently identify their own strengths and weakness, and how to improve upon them.

Here is another example of a modified rubric, this time for a math project about linear relationships:

Math Project: Linear Graphs		%
Assigning Group Responsibilities		10
Carrying out project requirements	group work & participation	10
Fullfilling Project Requirements (includes phases, or stages of completion)	By 90% By 80% By 70% 69% or lower - accompanying paragraph of what you think happened that didn't make you as successful as you could have been	50
Group Presentation of findings		
	Clarity	5
	Creativity	5
Description of experimental errors		10
Peer Review of job performance		5
Reflection on job performance and how you worked as a group		5
	Total	100

Projects capture other aspects of learning, namely those involved with working in and as a group. The ability to perform your responsibilities of your role greatly influences the outcome of your final product. Since most projects are larger than the capabilities of one person to handle, it is imperative that each project member do their job as best as they can. It is my hope that project-based learning is the key to learning this valuable skill, how to work in a group.

Another important aspect of carrying out a project is being able to have a report at various stages about your progress, to let your boss know whether or not you are on track to complete the project. As a teacher, I personally have experienced troubles setting these checkpoints in a project, because students always wanted to do things last-minute. If this rubric was given to the students before the project had started, and their grade was continually being added to at each checkpoint, then students would be more prone to continue with the pace that you lay out for them.

Presenting skills are vital in today’s business. Being able to persuade a group that your findings are accurate and important to them could be the difference in keeping your job or not.

Experimental errors are a way for students to see what they did wrong, and to decide whether or not it was an acceptable deviation from the expected results. In major companies, the smaller you can make this, the better chances you have of keeping your job, especially in the downsizing market that we are currently facing.

Hiker

Math Concepts

- Understanding the relationship between two variables
- Linear concepts of slope and y-intercept

Overview

Determining the relationship between distance and time using TI-83 and CBL for immediate feedback.

Materials

- Student capable of walking
- TI-83 with “Hiker” program installed
- CBL

Setup

Read over the setup procedures for the “Hiker” activity in order to understand how to use the program and setup the Hiker program.

Walk the Walk

1. Now we are going to have a volunteer go in front of the sensor and walk away from it towards the other side of the room in a straight line, and at a constant pace. Make sure this walk takes you about 5 seconds from start to finish.
2. Observe the graph that was made from this walk. What do you see?
3. Does distance depend on time? Does time depend on distance?
4. How can you tell how far away from the sensor that the student was at 3 seconds?
5. Why is the graph going up?
6. What do you think would happen if we did this again, but this time, the person walks faster? Let’s try it!
7. What happened to the graph?
8. What do you think will happen if we walk slower than before? Let’s try it!
9. Did the graph change as you expected?
10. Now let’s try starting farther away from the sensor. What do you think will happen to the graph?
11. What changed on the graph? Let’s try again but go faster. What do you think will happen?
12. Now let’s try walking towards the sensor, starting from the other side of the room. Remember to walk in a straight line. How do you think the graph will change?
13. How did the graph change?
14. Now try walking faster towards the sensor. How will it change?

15. Can you see a pattern from what happens when we walk away from the sensor and when we walk towards the sensor?

Conclusions

1. There is a relationship between the two variables distance and time.
2. As time goes on, the *farther away* you get from the sensor IF YOU WALK AWAY.
3. As time goes on, the *closer to* the sensor you get IF YOU WALK TOWARDS IT.
4. If you walk faster, for each moment of time, you are covering more distance. The graph gets *steeper*.
5. Depending upon how far away you *start* from the sensor, the graph starts higher or lower on the y-axis of the graph.

Rubric

Category		%
Assigning Group Responsibilities		10
Carrying out project requirements	group work & participation	10
Fullfilling Project Requirements (includes phases, or stages of completion)	By 90% By 80% By 70% 69% or lower - accompanying paragraph of what you think happened that didn't make you as successful as you could have been	50
Group Presentation of findings		
	Clarity	5
	Creativity	5
Description of experimental errors		10
Peer Review of job performance		5
Reflection on job performance and how you worked as a group		5
	Total	100

Car Collision

Math Concepts

- Making a model from data collected in the real world
- Proportions
- Slope
- $\text{rate} \times \text{time} = \text{distance}$
- Estimation

Materials

- 3 battery-powered toy cars that move at a constant speed
- TI-83+ Graphing Calculator
- MotionGE program
- Gauge program (Transformation Graphing application)
- CBR or CBL & motion sensor

Overview

Can 3 cars moving toward each other cross at an intersection at the same time without crashing?

Setup

Check the batteries in the toy cars

1. Remove the batteries from the cars.
2. Connect the volt meter to the lowest number channel on the CBL/CBR unit (channel 1 is the default).
3. Connect the CBL/CBR unit to the graphing calculator.
4. On the calculator, press “Apps” and then select “CBL/CBR.”
5. Run the program “Gauge”.
6. Make sure the settings show that the calculator is reading “volts” and then press “ok”. A gauge is displayed on the screen.
7. Connect the red and black probe connectors to the opposite ends of a battery and read the gauge on the calculator. For a AA battery, which comes charged at 1.5 Volts, a 1.2 Volt charge will be enough for this experiment.
8. If the charge is negative, reverse the red and black probe connectors.
9. If the charge is less than 1.2 Volts, replace the battery.
10. Continue testing the other batteries. Put the good batteries back in the toy car.
11. To quit “Gauge”, press the “ESC” key, or “ON” followed by “2: QUIT”.

Check the area in front of the motion sensor

1. Disconnect the volt meter and connect the motion sensor to the IDT port on the CBL/CBR unit, on the opposite side of the 3 channels.
2. Connect the CBL/CBR unit to the graphing calculator.
3. Clear the area in front of the sensor for a distance of at least 10 feet.
4. Place the sensor on the ground so that the part of the sensor taking the readings is perpendicular to the ground, pointed towards the wall.
5. On the calculator, press “Apps” and then select “CBL/CBR.”
6. Run the program “Gauge”.
7. Make sure the settings show that the calculator is reading “sonic”, the distance is reading “feet”, and then press “ok”. A gauge is displayed on the screen.
8. Place the car 2 feet away from the sensor and verify on the calculator that the gauge reads 2 feet. If the gauge does not read what is expected, then there is an object too close to the sensor. Move it out of the way and repeat the reading.
9. Repeat this process for 3, 4, 5, 6, 7, 8, 9, and 10 feet.
10. To quit “Gauge”, press the “ESC” key, or “ON” followed by “2: QUIT”.

Experiment

1. Now you are ready to test the toy car.
2. Place the motion sensor on the ground so that it is pointing straight at the wall ahead of it.
3. Position the toy car at least 1.5 feet away from the sensor in such a way that it will move away from the sensor when turned on.
4. Run the program “MotionGE” on the calculator. Press “enter” until it asks you for how many seconds you wish to collect data. Enter “5” seconds and continue (press “enter”). Wait to push the “trigger button” or until you hear a clicking noise (this tells you the sensor is working!).
5. As soon as the clicking starts, turn the toy car on and move yourself away from the sensor as fast as possible.
6. Once the clicking has stopped retrieve the toy car and turn off as soon as possible to preserve the life of the battery.
7. Now you have a curve displayed on the calculator. If you have a point that looks like it is out of place, repeat steps 1-6.

Questions

1. Looking at the graph, is it what you expected? Explain.
2. How fast is the car moving? How can you tell?
3. Now you are ready to place your cars so that they do not crash into one another at the intersection. Where will each car be in the intersection as they pass each other? Draw your design.
4. How far away from the intersection must each car be? How did you figure this out? *Hint: how fast is your car compared to the other cars?*
5. Position your cars to prepare for the big crash. On the count of 3, turn on your cars and release them to go towards the intersection. Do your cars crash? If so, explain what went wrong and how you will fix it. Then repeat steps 1-4.

Journal

What did you learn about this experiment? How did you go from a moving toy car to a function or more than one function? Why would anyone be interested in these results? Write your answer in a minimum of 1 paragraph, but no more than 1 page.

Teacher Notes

Common Errors

- Students will want to find the point where all the cars will meet at the intersection, when in fact at least one car needs to be going faster or slower than the other two in order to prevent a collision.
- Students will not be able to get a perfect answer to this problem, so when they find slightly different answers for the best fit equation to the data. This is caused by assumptions made by the students, and by the number of points that they use to model their quadratic functions with.

Remediation

- Students who are using similar rationales can be put into the same groups in order to help each other.
- Allowing students the chance to write a reflection on the activity allows for additional insight to student understanding, which can help augment their grade even if they didn't completely finish the activity.
- Students who still do not see the relationship will be given additional time in the form of homework on setting up and solving proportions.
- Students who are getting it faster than others will be asked to find the equation that best fits each change in the toy car's speed, using a quadratic regression, and then determining the point of intersection of the two functions. Then the class will have better data to work with, which will cause less confusion when they are determining the equation of the best fit linear curves.

Rubric

Category		%
Assigning Group Responsibilities		10
Carrying out project requirements	group work & participation	10
Fullfilling Project Requirements (includes phases, or stages of completion)	By 90% By 80% By 70% 69% or lower - accompanying paragraph of what you think happened that didn't make you as successful as you could have been	50
Group Presentation of findings		
	Clarity	5
	Creativity	5
Description of experimental errors		10
Peer Review of job performance		5
Reflection on job performance and how you worked as a group		5
	Total	100

Spinning Squares

Math Concepts

- Creating a model from real world data
- Multiple representations of information
- Pythagorean Theorem
- Ratios

Materials

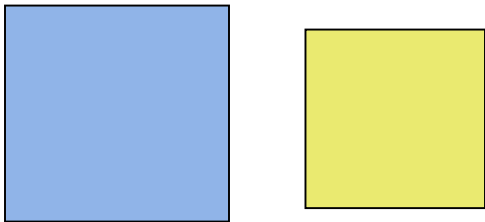
- Construction paper
- Scissors
- Ruler

Overview

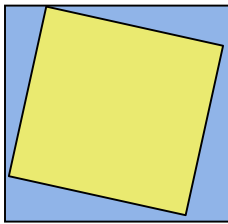
Investigating the mathematical relationships between two squares, one of which is spinning inside another.

Experiment

We have two squares, one bigger than the other.

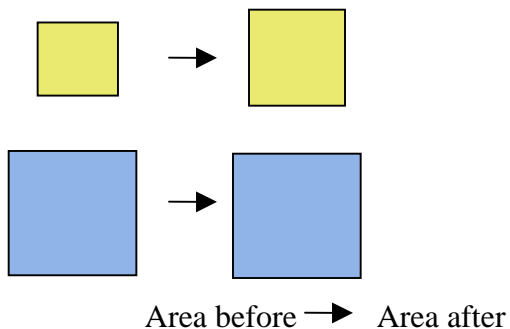


Condition: the corners, or vertices (plural of vertex), of the smaller square must always touch the sides of the bigger square. How can you do this? See the next picture for an example of how this condition can be met.

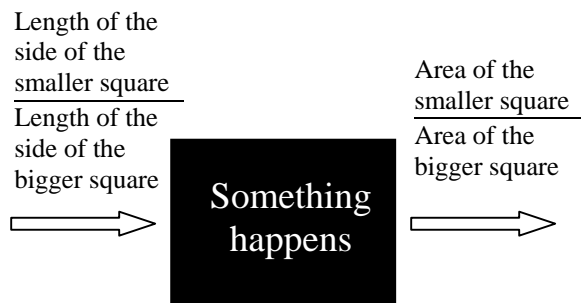


Now the question is: As the side length of the smaller square increases by some amount (a percent), how does the ratio of the area of the bigger square to the ratio of the smaller square change?

Goal as a Picture:



Goal as a Function:



4. What patterns do you see in the table you filled in?

5. As the smaller square gets smaller, what happens to the ratio of the side lengths? To the ratio of the areas?

6. **Journal:** What did you learn about this experiment? What can you conclude about changing the size of the smaller square? Write your answer in a minimum of 1 paragraph, but no more than 1 page.

Teacher Notes

Common Errors

- Students will not keep the vertices of the smaller square touching the sides of the larger square.
- Students think that by making a square with half of the side length, then the area will also be halved.

Remediation

- Students who are using similar rationales can be put into the same groups in order to help each other.
- Allowing students the chance to write a reflection on the activity allows for additional insight to student understanding, which can help augment their grade even if they didn't completely finish the activity.
- Students who are getting it faster than others will be asked to test their hypotheses of question 5. The slower students will use their data and verify the formula using the data in their tables.

Rubric

Category		%
Assigning Group Responsibilities		10
Carrying out project requirements	group work & participation	10
Fullfilling Project Requirements (includes phases, or stages of completion)	By 90% By 80% By 70% 69% or lower - accompanying paragraph of what you think happened that didn't make you as successful as you could have been	50
Group Presentation of findings		
	Clarity	5
	Creativity	5
Description of experimental errors		10
Peer Review of job performance		5
Reflection on job performance and how you worked as a group		5
	Total	100

Ball Bounce

Math Concepts

- Rate of change
- Proportions
- Exponential functions
- Discreteness
- Approximations
- Collecting data

Overview

Determining a relationship between the number of the bounce and the maximum height of the ball on that number bounce.

Materials

- Bouncing ball
- TI-83+ Graphing Calculator
- Bounce program
- CBR or CBL motion sensor

Setup

Connect the CBL or CBR motion detector to the TI-83+ graphing calculator and run the program Bounce. Wait at the screen that says to turn on the motion sensor.

Experiment

8. Hold the sensor above the ball facing downwards. As soon as you push the “Trigger” button on the sensor, let go of the ball. The sensor will start making a clicking noise, which lets you know it’s collecting data.
9. Once the clicking sound stops, the calculator will display a graph of the data just collected, which will be time versus distance from the sensor. What do you expect the graph to look like? Check your answer with the graph. Draw the graph that’s on the calculator.
10. If the graph has any flat spots or anything that doesn’t look like what’s expected, repeat steps 1-2.
11. Use the “Trace” feature of the graphing calculator to find the first full bounce on the graph. In a table, you will start off with bounce #1, height of bounce #1. Move the cursor over the closest point to the highest part of the bounce as possible and record in a table.
12. Repeat step 4 for every bounce that you can see.
13. Graph this table of data. What function do you think best fits this data? *Hint: use transformation graphing.*
14. Use the best example from the students to find a graph that best fits the data. Justify your answer.

Journal

What did you learn about this experiment? How did you go from a bouncing ball to an exponential function? Write your answer in a minimum of 1 paragraph, but no more than 1 page.

Teacher Notes

Common Errors

- Students may not know that the data from the CBR or CBL is not stored in L1, L2 on the graphing calculator, but in L2, L4.
- Students will not be able to get a perfect answer to this problem, so when they find slightly different answers for the best fit equation to the data. This is caused by assumptions made by the students, and by finding the maximum of each peak of the ball bouncing from only data points. The data will almost never be collected exactly at the maximum of a ball's bounce, but if a more advanced student took a quadratic regression of each ball bounce and then found the maximum of that equation, then a precise maximum could be found.

Remediation

- Students who are using similar rationales can be put into the same groups in order to help each other.
- Allowing students the chance to write a reflection on the activity allows for additional insight to student understanding, which can help augment their grade even if they didn't completely finish the activity.
- Students who still do not see the relationship will be given additional time in the form of homework on setting up and solving proportions.
- Students who are getting it faster than others will be asked to find the equation that best fits each ball bounce using a quadratic regression, and then determining the exact maximum of each peak. Then the class will have better data to work with, which will cause less confusion when they are determining the equation of the best fit exponential curve.

Rubric

Category		%
Assigning Group Responsibilities		10
Carrying out project requirements	group work & participation	10
Fullfilling Project Requirements (includes phases, or stages of completion)	By 90% By 80% By 70% 69% or lower - accompanying paragraph of what you think happened that didn't make you as successful as you could have been	50
Group Presentation of findings		
	Clarity	5
	Creativity	5
Description of experimental errors		10
Peer Review of job performance		5
Reflection on job performance and how you worked as a group		5
	Total	100

The Logistics are Mind-Boggling

Math Concepts

- Creating a model from real world data
- Exponential growth
- Logarithmic growth
- Discrete data
- Randomization
- Asymptotic bound

Materials

- TI-83x Graphing Calculator

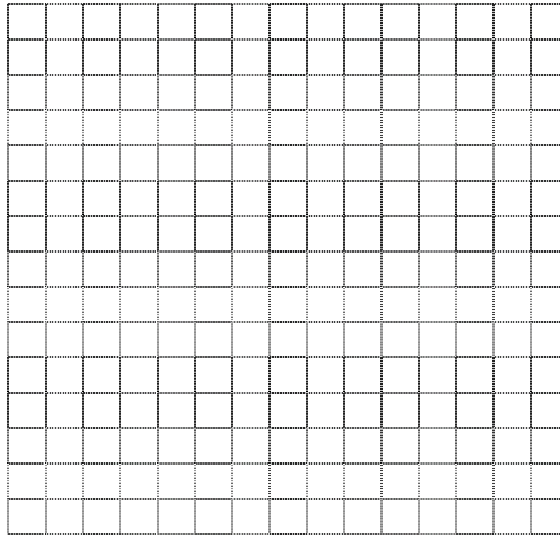
Overview

Investigating how real world constraints alter the pure exponential function in a game about who told a rumor in school.

Experiment

Who told who? That is for one to know and for the rest to find out! There is a school of 30 students where a guy kissed Julie, and then Julie was so grossed out she wanted to tell her friends to stay away from him. She told two of her friends, and the two of them each told two more, and so on. Pretty soon everyone in the entire school knew about this guy except the guy! Who was the last one to find out?

Step 1: Make a sketch of the number of times the rumor has been told vs. the number of students who know the rumor.



Step 2: Enter names in the table until it is entirely filled in.

Julie	1	2	3	4	5
6	7	8	9	10	
11	12	13	14	15	
16	17	18	19	20	
21	22	23	24	25	
26	27	28	29	30	

Step 3: With your TI-Graphing calculator, we are going to randomly pick who gets told. We must make an assumption that these people are all told at the same time during the day, such as in between classes. Using your calculator, enter the following key strokes:

Key Strokes for your TI-83x calculator:

1. Press the “MATH” key

```

MATH NUM CPX PRB
1: Frac
2: Dec
3: 3
4: 3√(
5: *√
6: fMin(
7: fMax(

```

2. Then arrow over to “PRB” for probability

```

MATH NUM CPX PRB
1: rand
2: nPr
3: nCr
4: !
5: randInt(
6: randNorm(
7: randBin(

```

3. Down to #5 “randINT(“ and press the “ENTER” key

```

randInt(

```

4. Now we can see who is gossiping to the rest of the school. At first, the only person who can gossip is the girl, so we enter the following:

```

randInt(1,30,1)

```

This means the girl randomly chose to talk to somebody in the group of 30 people, which are the thirty in your table. The function **randINT()** has 3 parameters:

lowest number to pick, highest number to pick, how many to pick

For the first rumor to be told, Julie must pick between the group of 30 people, and since every person has a number in your table, we represent them as the numbers 1-30 in this function. Since she can only tell one person, as the rules state, the last parameter to randINT is 1. Go ahead and press “ENTER”.

```

randInt(1,30,1)
(2)

```

NOTE: lowest number to pick = 1, highest number to pick = 30 ALWAYS

The person that Julie randomly picked to tell the rumor to is person #2. Note, your calculator may choose a different number. This is OK and you should cross out that number in your table instead.

5. How many people know the rumor now? In the next table, enter this number:

# of times rumor spread	# people who know the rumor
1	2
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

the

6. Now we can repeat steps 1-4:

```

randInt(1,30,2)
(3 1)

```

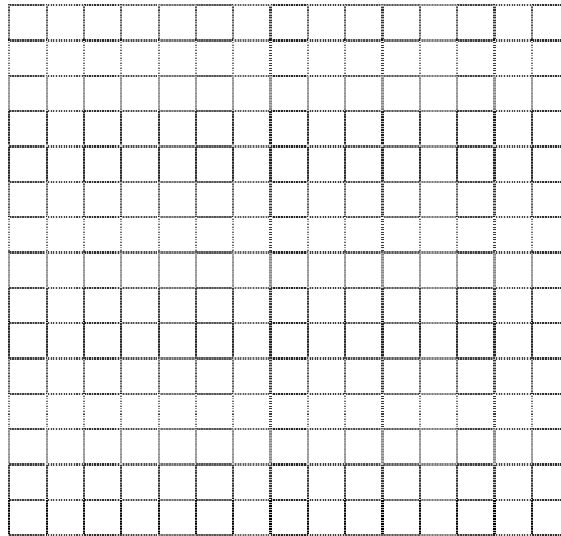
So Julie and person #2 (or your number) have chosen to tell person #3 and person #1 the rumor. But person #1 is Julie, and she already knows! So when you cross off names this time, you don't need to cross out her name again. **NOTE: the 2 will be changed to a 3 in the function next time because 3 people know.**

7. How many people know the rumor now? Enter this number in the table to the left.

8. Repeat steps 1-6 until every name but 1 has been left. The last person to know is the person who the rumor is about. Write the person's name here: _____

Step 4:
Take
data
from

the table above and plot the points on the graph below. Label the axes.



Step 5: Compare your actual graph with your original? How are they different? How are they the same?

My Graph

Actual Graph

Journal:

What did you learn about this experiment? What do you notice about the number of people how know the rumor as it is told each time? Write your answer in a minimum of 1 paragraph, but no more than 1 page.

Teacher Notes

Common Errors

- Students will not update the 3rd argument in the randINT function each time.
- Students will connect the data points even though the data is discrete
- Students will continue the line they incorrectly drew to show that the domain is all reals, which is an incorrect assumption about the start and end of the rumor spreading

Remediation

- Students who are using similar rationales can be put into the same groups in order to help each other.
- Allowing students the chance to write a reflection on the activity allows for additional insight to student understanding, which can help augment their grade even if they didn't completely finish the activity.
- Students who are getting it faster than others will be asked to find a function family that will best fit portions of the graph. The slower students will use their data and verify the formula using the data in their tables.

Rubric

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	Total	100

Walk Towards the Light

Math Concepts

- Creating a model from real world data
- Trigonometry
- Reflection
- Domain and Range

Materials

- Flashlight
- Mirror
- Meter stick
- Tape

Overview

Investigating the effects of light reflecting on a mirror at different angles.

Experiment

How does a mirror work? You can only see yourself when you're right in front of it, but you don't see yourself when you are anywhere else. Why is that?

Let's find out!

Step 1: Using the meter stick, position the mirror $\frac{1}{2}$ meter away from the wall. Position yourself 1 meter away from a wall.

Step 2: Find a comfortable height to hold the flashlight at. Record this height from the ground: _____ m

Step 3: Turn on the flashlight and point it at the mirror. Have another person use the tape to measure where the light shines on the wall. What part of the lighted wall are you measuring? The bottom, center, top, other?

Step 4: Repeat step 3, each time being a difference distance away from the wall. Fill in the missing information in the table:

Distance from wall (m)	Height of light on wall (m)
1.00	
1.25	
1.50	
1.75	
2.00	
2.25	
2.50	

Step 5: What can you conclude from looking at the table? Make a hypothesis about what is happening.

Step 6: Test your hypothesis for at least *three different heights* not listed in the table. Record answers below.

Distance from wall (m)

Height of light on wall (m)

Step 7: Was your hypothesis correct? Why or why not?

Step 8: What do you think would happen if the mirror were moved closer to the wall and you repeated this experiment? Try it out and write your conclusions here.

Hypothesis:

How I plan to test my hypothesis:

Data I collected:

Conclusions I made:

Journal:

What did you learn about this experiment? Why would someone want to study how light reflects against shiny objects like a mirror? Write your answer in a minimum of 1 paragraph, but no more than 1 page.

Teacher Notes

Common Errors

- Students will not consistently hold the flashlight at the same height.
- Students will not consistently measure the light beam in the same place.

Remediation

- Students who are using similar rationales can be put into the same groups in order to help each other.
- Allowing students the chance to write a reflection on the activity allows for additional insight to student understanding, which can help augment their grade even if they didn't completely finish the activity.
- Students who are getting it faster than others will be asked to find a function family that will best fit the data. The slower students will use their data and verify the formula using the data in their tables.

Rubric

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Swing Low, Sweet Chariot

Math Concepts

- creating a model from real world data
- sinusoidal function $A \sin(B(x - C)) + D$
- amplitude
- period
- phase shift
- vertical shift
- development of physical relationships of pendulum speed, length, period, weight

Materials

- TI-83+ Graphing Calculator
- transformation graphing, data logger, and gauge programs installed on TI-83
- CBR or CBL & motion sensor
- TI-ViewScreen
- Projector
- 6' thin wire, such as fishing line or piano wire
- weight with hook to attach to string

Overview

We are going to investigate the properties of a weight swinging back and forth on a wire.

Setup

11. Using the wire, attach one end to the weight and the other to a secure overhead object. Adjust the length of the wire so that the weight hangs freely from the overhead object. You have just created a *pendulum*.
12. Now wait for the pendulum to stop moving.
13. Position the CBL/CBR so that the sensor part of the unit is facing the pendulum head on and not at an angle. You will need an object of the correct height in order for this to work properly.
14. Connect the CBL/CBR unit to the graphing calculator.
15. On the calculator, press “Apps” and then select “CBL/CBR.”
16. Run the program “Gauge”.
17. Make sure the settings show that the calculator is reading “sonic”, the distance is reading “feet”, and then press “ok”. A gauge is displayed on the screen.
18. Record how far away the pendulum is from the CBL/CBR when it is motionless. Does this measurement make sense? If not, then something is in the way. Move it and repeat this step.
19. Place a flat surface about a foot behind the pendulum on the side away from the CBL/CBR. This is going to be where you initially release the pendulum from. Make sure it is as tall as the pendulum weight pulled back to touch it.
20. Pull back the pendulum about 1 foot from its resting position to your flat surface. Mark where the pendulum touches the surface so you can start from here again.
21. Record how far away the pendulum is from the CBL/CBR.
22. To quit “Gauge”, press the “ESC” key, or the “ON” key followed by the menu option “2: QUIT”.

Experiment

15. Pull back the pendulum back to touch the mark you made on the flat surface.
16. Now we need to find out how long it takes the pendulum to swing one complete cycle. The more cycles you calculate, the more accurate your final answer will be.
17. Use the following formula to determine the *period of the pendulum*:

$$period = \frac{time}{numberofcycles} \text{ seconds}$$

18. On the calculator, press the “APPS” key, and then select the menu option “DATALOGGER”. Your units will be feet. In order to show 2 complete swings, or cycles, of the pendulum, the time interval needs to be $2 * period$. The sensor needs to take a reading AT LEAST every $(2 * period / 13)$ seconds.
19. Once you press “OK”, release the pendulum. Make sure that you do not make the pendulum spin or swing at an angle that is not straight in front of the sensor. If you do, stop the pendulum, and repeat steps 1-2.

20. Now you have a curve displayed on the calculator.
21. Push the “ON” key, and then select the menu option “QUIT”.
22. Press “2nd” “Y=” and see if Plot1 is on. If it is not, turn it on now.
23. Press “Apps” and then “Transform”. Your data will appear and so will a graph. What do the values of A, B, C, and D need to be in order to fit the data graphed?

Questions

6. Looking at the graph, is it what you expected? Explain.
7. What does the A represent?
8. What does the B represent?
9. What does the C represent?
10. What does the D represent?
11. What happens if we change the weight of the pendulum? Repeat experiment steps 1-9 and answer questions 1-5. How is this graph different?
12. What happens if we start the pendulum back farther from the resting position than we had originally? Repeat experiment steps 1-9 and answer questions 1-5. How is this graph different?
13. What happens if we use a different length pendulum? Repeat experiment steps 1-9 and answer questions 1-5. How is this graph different?

Journal

What did you learn about this experiment? What can you conclude about changing these characteristics of the pendulum? Which ones make a difference and which do not? Why would anyone be interested in these results? Write your answer in a minimum of 1 paragraph, but no more than 1 page.

Teacher Notes

Common Errors

- Students will not measure the amplitude correctly because of the width of the pendulum.
- Releasing the pendulum without making it spin or swing at an angle to the sensor.
- The model will never match the graph because of a phase shift. Advise students to find the first maximum of the data using the “TRACE” feature of the calculator, and use that x-offset as the phase shift D for the sinusoid.

Remediation

- Students who are using similar rationales can be put into the same groups in order to help each other.
- Allowing students the chance to write a reflection on the activity allows for additional insight to student understanding, which can help augment their grade even if they didn't completely finish the activity.
- Students who are getting it faster than others will be asked to test their hypotheses of questions 6-8. The slower students will use their data and find another best-fitting sinusoid graph.

Rubric

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