Context in Content: The Purpose of Project-Based Learning in Mathematics

NCTM Annual Conference 2017 https://tinyurl.com/NCTM-PBL

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PBL / PrBL Resources:

Title	URL	Short Description
ARiE PBL Training	http://advancedreasoningined.com/	PBL Training Resources
PBLife Blog	https://pblife.edublogs.org/	PBL blog from Math and Science PBL Guru
Math Assessment Project	http://map.mathshell.org/	Great tasks mapped to CCSS to build projects off of
Dan Meyer Blog	http://blog.mrmeyer.com/	Math blog from Dan Meyer
Desmos Activity Builder	https://teacher.desmos.com/activitybuilder	Create activities in Desmos to send to students!
Graphing Stories	http://graphingstories.com/	Similar to 3 act tasks, includes videos and worksheets, has them create stories for graphs
Plotly	https://plot.ly/	Create Charts and organize data -- better than google spreadsheets
Emergent Math Blog	http://emergentmath.com/	Blog by Geoff Kroll, New Tech Network Coach, PrBL CCSS aligned curriculum maps with tasks
Andrew Stadel 3 Act Math Tasks	https://tinyurl.com/3ActAStadel	3 Act Math Tasks
Robert Kaplinsky PrBL	https://tinyurl.com/PrBLKaplinsky	Problem Based Lessons - Geometry/Algebra
Dan Meyer 3 Act Tasks	https://tinyurl.com/3ActDMeyer	Links to all Dan Meyer 3 Act Tasks
3 Act Livebinder	https://tinyurl.com/3ActLiveBinder	Livebinder with endless amounts of tasks from Dan Meyer and Many others
Nasa: Exploring Space through Math	https://tinyurl.com/NASAMath	Lessons for Algebra, Alg. II, Geometry, and Precalculus
Budgeting blog	http://mathbudget.weebly.com/	In-depth resource for planning career and budget project
NTN PrBL units for math	https://tinyurl.com/NTNPrBL	New Tech Network shared spreadsheet for problem based math

Sample PBL Rubric Template

Math Standard (Application)	Emerging (Remembering)	Proficient (Application)	Advanced (Synthesis)

21st Century Skill	Emerging (Remembering)	Proficient (Application)	Advanced (Synthesis)

Notes:

Sample PBL Calendar Template

Monday	Tuesday	Wednesday	Thursday	Friday

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Pedro Merced

Sarah DiMaria

Experience: 4 years Project Based Instruction, PBL consultant

Courses Taught: Algebra 1 & 2, Geometry, PreCalculus, Calculus, Statistics, Physics, Astronomy, 8th Grade Math

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CEDARS INTERNATIONAL ACADEMY

MICHIGAN STATE UNIVERSITY

Advanced Reasoning in Education
Think Global PBL Academy

KSTF
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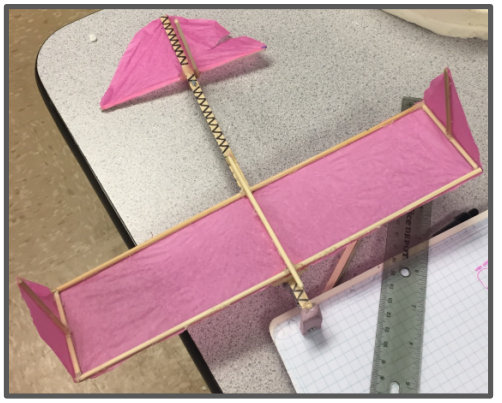
UTeach
THE UNIVERSITY OF TEXAS AT AUSTIN

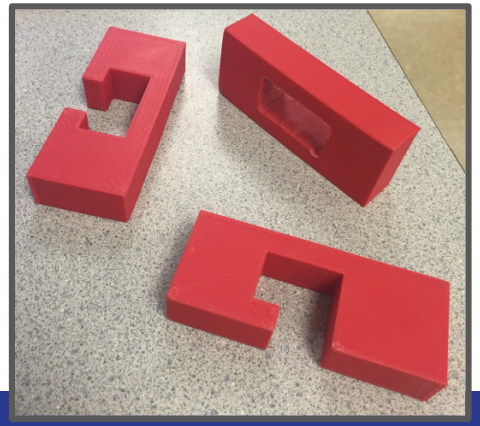
AUSTIN COMMUNITY COLLEGE

Project Based Learning Overview

Essential Elements of PBL

- Entry Event and Driving Question
- Knows and Need to Knows
- Rubrics
- Scaffolding and Assessment
- Presentation





Project Based Learning Reasoning

Students have better recall of topics when linked to a project instead of a chapter in a book

Students get better at managing time (because they have to)

Prepare students for the workforce by developing their “soft” skills

Rubrics

Online handout: https://tinyurl.com/NCTM-PBL

In what ways does the rubric serve the **teacher**?

In what ways does the rubric serve the **students**?

Characteristics of Good Descriptors

Observable and quantifiable

Balanced between specificity and open-ended

Use academic vocabulary

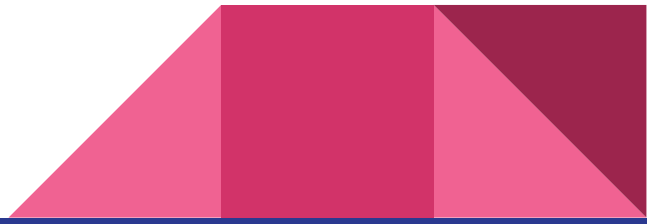
Objective

Set positive expectations

Address the product

Tie back to the standards

Quality and Rigor vs. Quantity



Constructing a Rubric

Standard	Emerging (Remembering)	Proficient (Application)	Advanced (Synthesis)
List the math standard or 21st Century skill in this column	**Emerging** column should be basic skill qualities	**Proficient** column should show gradual improvement in quality	**Advanced** column should show highest quality that students at this stage should demonstrate.

Build in Bloom's Taxonomy

8th Grade Math Example: Roller Coasters

Driving Question: How can we as roller coaster engineers use slope and proportionality to design a roller coaster that maximizes velocity and acceleration in order to improve our theme park's attractions?

Math Standard (Application)	Emerging (Remembering)	Proficient (Application)	Advanced (Synthesis)
8.4A Use similar right triangles to develop an understanding that slope, *m*, given as the rate comparing the change in *y*-values to the change in *x*-values, $(y_2 - y_1)/(x_2 - x_1)$, is the same for any two points (x_1, y_1) and (x_2, y_2) on the same line.		For each section, group is able to: Correctly **calculates** and labels slope and distance using similar triangles **Explains** calculations within the context of their rollercoaster	

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21st Century Skills Rubric

- Digital Literacy
- Written Communication
- Oral Communication
- Collaboration
- Work Ethic
- Global Citizenship

What skills do my students need to be successful in the workplace?

21st Century Skill Example: Oral Communication

21st Century Skill	Emerging (Remembering)	Proficient (Application)	Advanced (Synthesis)
Oral Communication	**Presentation Skills** Makes minimal use of presentation skills including body posture, eye contact, voice volume and pace Presenter's energy and affect are unsuitable for the audience and purpose of the presentation	**Presentation Skills** Demonstrates a command of some aspects of presentation skills including body posture, eye contact, voice volume and pace Presenter's energy, and/or affect are usually appropriate for the audience and purpose of the presentation, with minor lapses	**Presentation Skills** Demonstrates a command of presentation skills, including control of body posture and gestures, eye contact, clear and audible voice, and appropriate pacing Presenter's energy and affect are appropriate for the audience and support engagement

Adapted from New Technology Network Rubrics

Rubrics: Essential tools for instruction

Visible

Interactive

Peer and Self Assessment Tool

Student Friendly

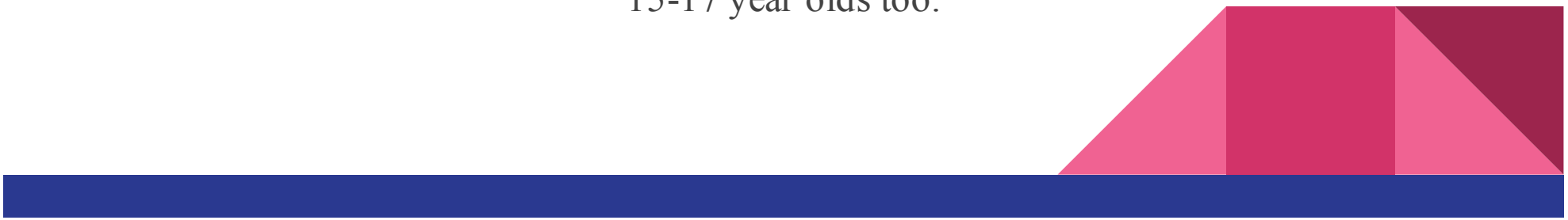
Accessible

Calendar
and
Day to Day in the Project

Online handout: https://tinyurl.com/NCTM-PBL

Calendar

This is an overview of the types of days that might occur throughout the scope of a project. This is by no means a hard to do list, but rather an **exploration** of the ways you can manage your class through the project itself. The important thing to remember is to **be flexible** and try to be in **tune with your students needs**. This changes from project to project and can change from day to day. Plotting down a **tentative calendar** is a good idea, but by no means feel that this is a hard document. Part of the **magic of PBL is the trust and freedom** that is given to the students to learn and explore. Remember, if a Kindergarten teacher can run centers in their class with 23 six year olds, you can do it with 15-17 year olds too.



Calendar

Still doing all the things you are doing. Best practices, hands on activities, etc

Monday	Tuesday	Wednesday	Thursday	Friday
Launch Day K/NTK Rubric				
			Presentations	Test

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Still doing all the things you are doing. Best practices, hands on activities, etc

Monday	Tuesday	Wednesday	Thursday	Friday
Launch Day K/NTK Rubric				
	Quiz			Quiz
	Final Check in/Mock Presentations	Build Day/ Clean Ups/ Buffer	Presentations	**TEST**

Calendar

Still doing all the things you are doing. Best practices, hands on activities, etc

Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Launch Day K/NTK Rubric	Lecture/ Brainstorming	Workshops/ Centers	Workshops/ Centers	
Workshops/ Centers	Quiz			Quiz
	Final Check in/Mock Presentations	Build Day	Presentations	**TEST**

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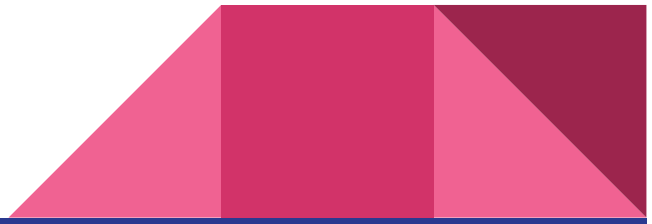
Still doing all the things you are doing. Best practices, hands on activities, etc

Monday	Tuesday	Wednesday	Thursday	Friday
Launch Day K/NTK Rubric	Lecture/ Brainstorming	Workshops/ Centers	Workshops/ Centers	Build Day/ Team Check in/Buffer
Workshops/ Centers	Quiz/ Reflections Journals	Team Check in/ Centers	Build Day	Quiz
Build Day/ Workshops	Final Check in/Mock Presentations	Clean up and Build day	Presentations	Test

Launch Day

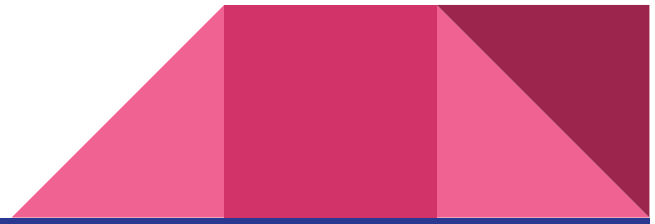
- Intro the lesson through the lens of the final product.
  - Give the “What” and “Why”
  - before studying the “How”
- Go over Knows/Need to Knows
  - gauge student learning
  - Misconceptions
  - connections to previous materials.
- Go over the Rubric
  - Clear communication of Goals
  - Learn more about this step from Sarah!



Workshops/Centers

A mixture of many different activities

- Small group instructions
- Activities tied to the final product
- Build Day
- Individual worksheets and practice problems
- Individual research on overarching topic
- Individualized learning through any number of media
- Enrichment and remediation activities
- Team Check In



Team Check In Day

Check in with each team

Gauge the progress of final product

Ensure collaborative environment within the class and groups

Ensure fair and equitable work distribution

Project Examples

http://tinyurl.com/PBLMathSample

Project Ideas and Standards

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Pedro Merced
NCTM 2017

8th Grade - Join the Club

For the first project of the year (and EVER for 8th graders) students surveyed the entire school to figure out which clubs the student body was interested in hosting on campus. Students learned mean, median, mode, range, absolute mean deviation and various methods of collecting and graphing data. Data was analyzed, presented and used to start actual clubs on campus.

Standards: determine the mean absolute deviation and use this quantity as a measure of the average distance data are from the mean using a data set of no more than 10 data points; simulate generating random samples of the same size from a population with known characteristics to develop the notion of a random sample being representative of the population from which it was selected

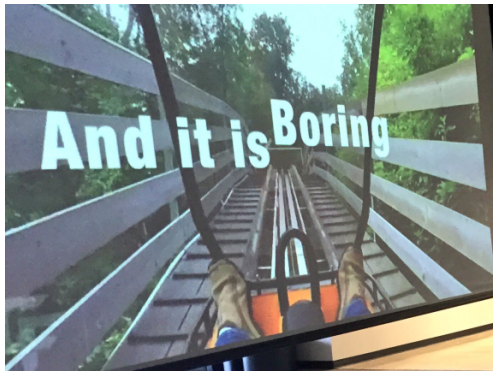
Driving Question: How can we as students in a new school research and start clubs on campus that are of high interest to the student body?

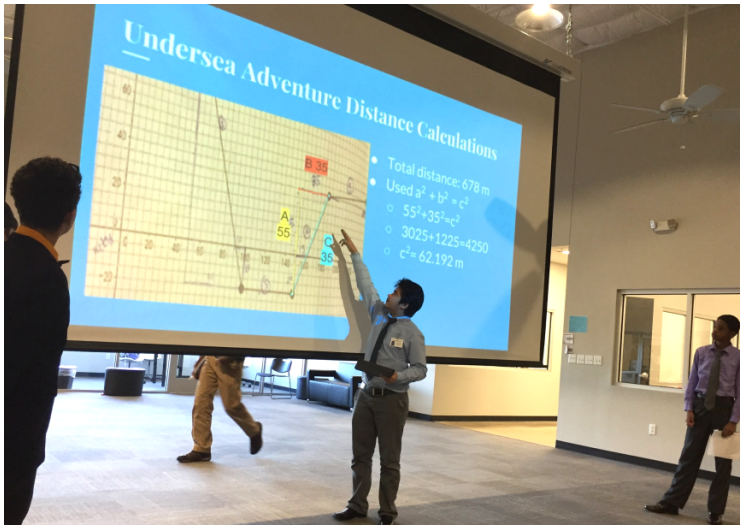
Duration: 4 weeks, 2 phases

End Product:
Club Data analysis posters and club start ups

8th Grade - Rollercoaster Tycoon

8th grade students learned about slope and proportion, velocity and acceleration through the lens of a rollercoaster. This project integrated their math and science courses for three and a half weeks as they made calculations in one class and analyzed in the other.





Standards:

8.4A Use similar right triangles to develop an understanding that slope, m, given as the rate comparing the change in y-values to the change in x-values (y2 - y1)/(x2 - x1) is the same for any two points (x1, y1) and (x2, y2) on the same line.

8.4C Use data from a table or graph to determine the rate of change or slope and y-intercept in the mathematical and real-world problems.

Driving Question:

How can we as roller coaster engineers use slope and proportionality to design a roller coaster that maximizes velocity and acceleration in order to improve our theme park's attractions?

Duration:

3.5 weeks

End Product:

Rollercoaster Analysis and Digital Model

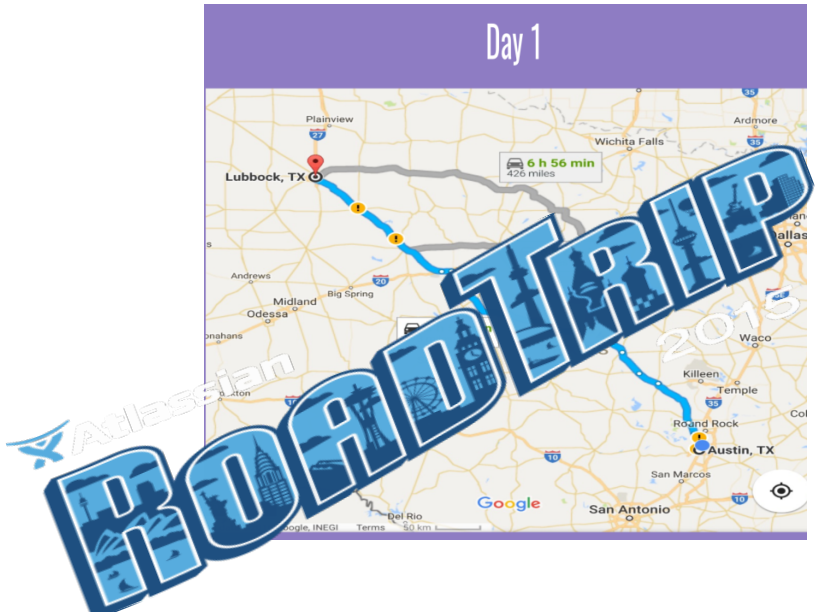
Calculus - Iron Rattler

Students engaged in a three week project to break down and redesign a roller coaster of their choice. The students manipulated 3 different parts of the roller coaster to make drops more steep, loops that had higher exit velocities, yet maintaining continuity and differentiability throughout the coaster to ensure safety.

Standards: Continuity, derivitives, differentiability at a point
Driving Question: How can we as Theme Park Engineers, take the Iron Rattler and improve on its “thrill factor” while maintaining safety
Duration: 3 weeks
End Product: 2-d Rendering of the roller coaster with functions to map the ride.

Algebra 1 - Road Trip!

Students planned a 5 day road trip across the US calculating costs for everything, creating linear equations to model situations and reporting expense reports and an intinrary for their trip. Students prepared for unexpected stops and navigated through them mathematically!



Standards:
A.5(A) solve linear equations in one variable, including those for which the application of the distributive property is necessary and for which variables are included on both sides
A.2 (A) determine the domain and range of a linear function in mathematical problems; determine reasonable domain and range values for real-world situations, both continuous and discrete; and represent domain and range using inequalities
A.12(A) decide whether relations represented verbally, tabularly, graphically, and symbolically define a function (B) evaluate functions, expressed in function notation, given one or more elements in their domains (E) solve mathematic and scientific formulas, and other literal equations, for a specified variable.

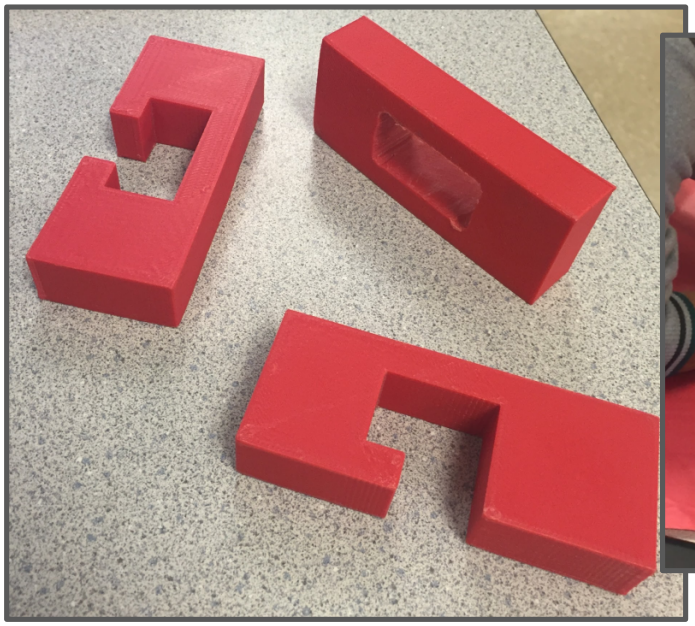
Driving Question:
How can we as travelers prepare for and "take" a road trip across the US?

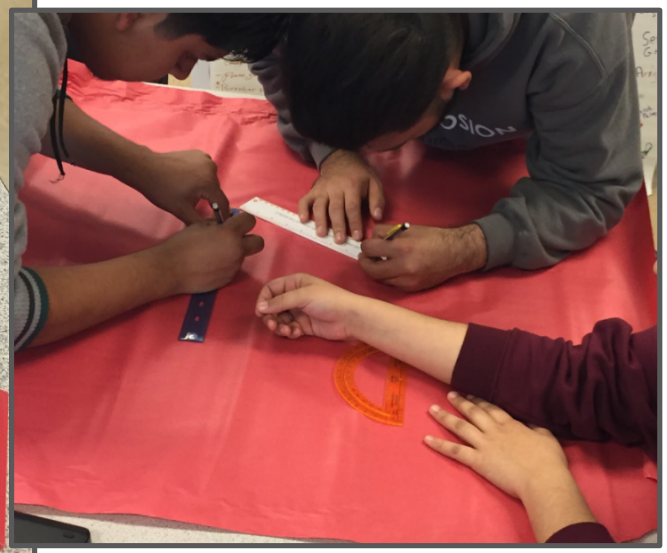
Duration: 3 Weeks

End Product:
Itinerary and road trip presentation

Calculus- 3D Printing Investigation

Students chose a topic in calculus to continue to study and present their findings after the AP exam. Many groups chose 3D modeling and expressed their talents by printing puzzles, teaching solids, and toys to review solids.





Standards: **Analyze mathematical relationships to connect and communicate mathematical ideas.**

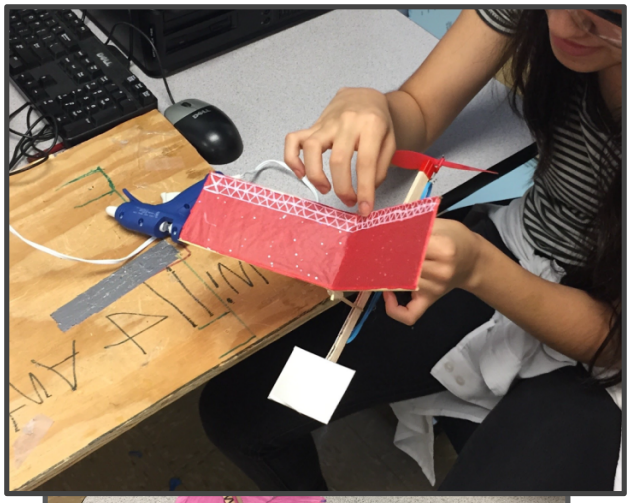
Driving Question: How can we a perspective college students demonstrate our knowledge of Calculus?

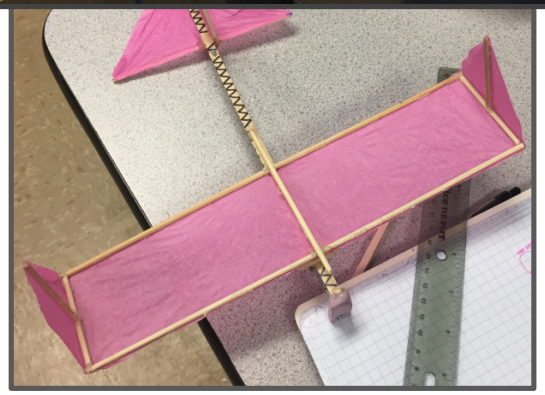
Duration: 3 weeks

End Product: printing puzzles, teaching solids, and toys

Geometry - Flying Solo

Geometry and engineering students studied flight through lines and angles to create planes structured for height, length and weight bearing. Students independently designed but competed as a team.





Standards: Select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems; Investigate patterns to make conjectures about geometric relationships, including angles formed by parallel lines cut by a transversal

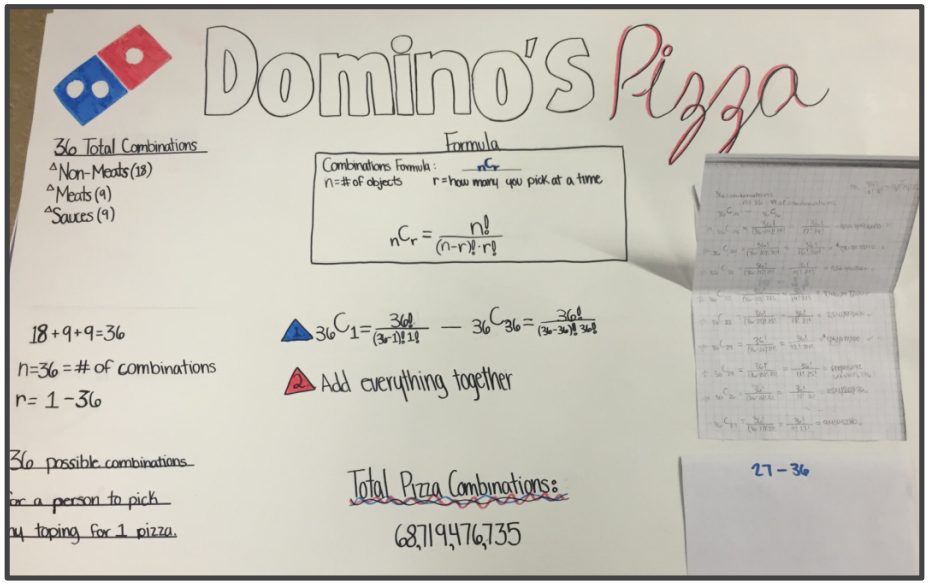
Driving Question: How can we as flight team members create a team of planes to succeed in competition?

Duration: 3 weeks

End Product: 3 planes to compete in school flight team competition.

Geometry - Domino's Pizza

Domino's put out an article claiming they had over a million types of pizza combinations. Students set out to find all of the combinations Domino's offered then actually sent letters to domino's explaining their thinking after having a debate in class defending their answers.



Standards: **Develop strategies to use permutations and combinations to solve contextual problems**
Driving Question: Domino's claims over a million combinations of pizza, how can this be true?
Duration: 1 week
End Product: Poster and letter to Dominos

AlgII or Pre Cal - The Power of Savings (the curse of debt)

Students engage with an adult to serve as a financial planner. Students use prospectus data to approximate percentage growth and project the potential earnings of the invested money from the adult they are working with. Students have the option to "build" an excel calculator in order to show the final earnings and amount in each account.

Alternately, students are given a mismanaged credit card account and the students come up with a plan to manage the debt. Throughout the project the students also get "life events" that put a damper on the plan. At the end the students report on success of the project.

Standards:
AII(5) A-D
PC(2) A,E,F,G,I
(logarithmic and exponential functions

Driving Question:
How can we, as an informed consumer, create a portfolio in order to set up my desired retirement

Duration: 3 weeks

End Product:
Financial plan for a teacher on campus based on financial goals

Algebra I - Pirate's Revenge

Students explore an application of the linear function through the lens of buoyancy and density. Students construct, or are given boats, and they have to calculate the density of the object. Students are led through a variety of labs and activities to learn about the linear function and linear inequalities in order to contextualize the content. On the presentation week, students are asked to construct a boat and accurately predict, using a mathematical model, how much weight the boat can hold without sinking.

Standards:
A(2)A-D Linear Equation
A(3)A-F Systems and Linear Inequalities

Driving Question:
How can we, as pirates, accurately predict how much gold our boat can hold

Duration: 3 weeks

End Product:
Demo of boat capacity

Geometry - Mini Elements

This is a beginning of the year project that has students create a picture dictionary that they keep and add to for the entire year. As students add to this they read and learn about Euclid's Elements and the importance of words and definitions in Mathematics. Students also engage in small proofs and how to explain and justify work in the geometry classroom.

Standards: G(4) A-C (proof and logical argument) G(5) A-C (logical argument and constructions)
Driving Question: How can we as Math Students decode and understand the language of geometry to ground us with a common language
Duration: 3 weeks/all year
End Product: Pamphlet and course dictionary with pictures of geometric ideas

Algebra II - CSI

Students are put into the roles of CSI and detectives trying to solve a murder. The project launches with a crime scene and through the gathering of evidence the students try to solve the crime. Students learn about exponential and logarithms through Newton's Law of cooling and the logarithmic relation of blood spatter labs. The end product is a CSI report linking the evidence to one of the suspects.

Standards:
AII(5) A-E (exponential and Log equations)

Driving Question:
How can we as CSI collect and analyze data in order to solve a murder mystery

Duration:
4 weeks

End Product:
CSI Report