

Project-Based Learning in Precalculus

El Paso Community College

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AMATYC 2020

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STEMGROW

- Department of Education grant
- Collaboration between UTEP and EPCC
- Total \$6 million for 5 years
- Components include biology, engineering, math(PBL), makerspace.





Project Based Learning



21st Century Skills

Critical Thinking

Creativities

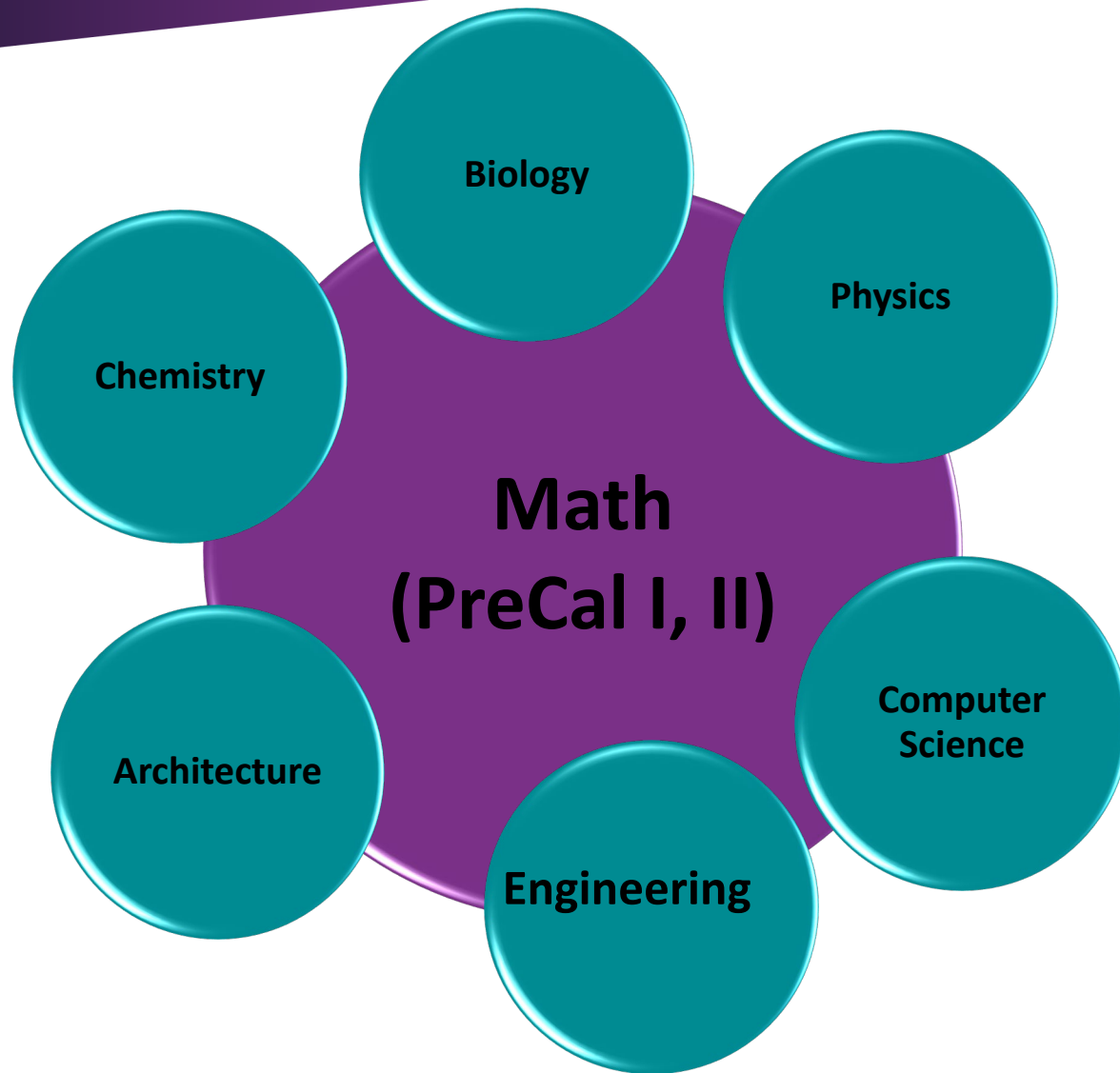
Collaboration

Communication



PBL creates a learning
environment for the
21st century skills

PBL in PreCalculus





PBL in PreCalculus



- Making your own yogurt using kefir
- Designing a bridge
- Designing a roller coaster for a local playland
- Designing electrical toy to donate to the shelter
- Creating art work with circuit
- Creating a calculator app



Computer Science Project

- Pre-calculus I – College Algebra
- 25 students
- Face-to-face
- Exams, homework, lab, and project
- Project completed outside of class

Motivation

Dear Students:

My name is John Smith – I am the founder of Engineering Components Incorporated, ECI. Since our inception in 1985, our company has been heavily dependent on highly mathematical processes. Throughout our history, we have had the luxury of working with highly skilled engineers that have designed and implemented these processes. However, it has been our experience that as engineers move on in their careers and leave the company, they take with them the knowledge and skills of all the mathematical processes that we use in manufacturing the different company's products. This has forced us to invest significant resources hiring and re-training new engineers.

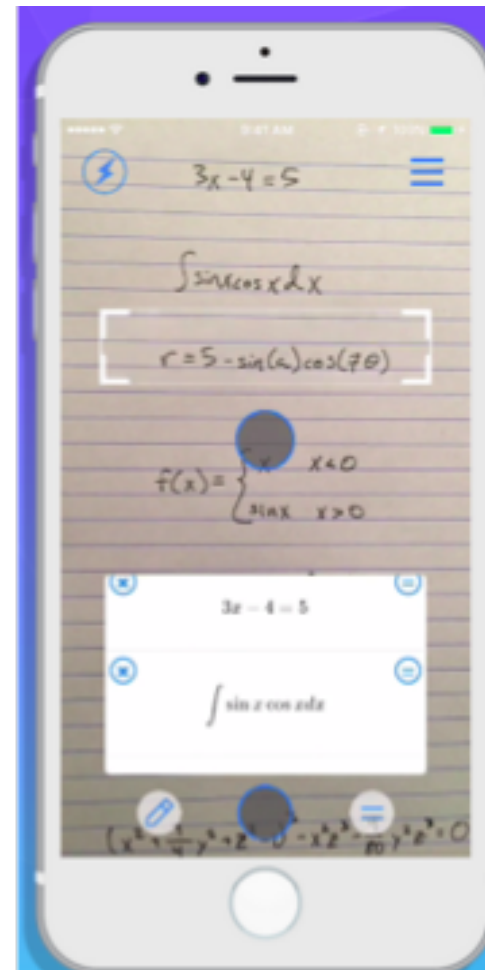
Rather than spend the time finding and training new engineers and ultimately keep risking the same outcome, the company would like to replace some of the engineers with mobile apps that can be used by anyone to make and verify the computations they need to do.

We have a list of mathematical processes that we would like to have implemented as mobile apps and are now looking for students to help us implement these as we don't have the technical resources to do this. Should you decide to accept this challenge, and successfully complete the project, ECI would like to reward any student teams that complete the project with Internships next summer.

John Smith

John Smith

Letter from local industry



Project Description



- Create a mathematical mobile application
- Groups of 3-4 students
- Select topic(s) from course objectives

Deliverables



- Team contract
- Journals
- Codes
- Manual calculation side-by-side comparison
- Report/presentation

Materials and Resources



- Access to computer/tablet/phone and internet
- OER coding



Sample Student Topics

- Distance formula between two points in the xy -plane
- Find x - and y -intercepts given the equation of a graph
- Solve a quadratic equation
- Solve a system of linear equations of two or three variables
- Find the determinant of a square matrix

Mathematical Mobile App



The screenshot displays the BuildFire web application builder interface. On the left is a sidebar menu with options: Dashboard, Design, Add Media, Home Screen (selected), Features, Commerce, Notifications, Users, Analytics, Settings, and a Developers button. The main workspace is divided into several sections. At the top, there's a header with the BuildFire logo, a "Let Us Build Your App" button, a "Publish" button, a "math try" dropdown, a "Select Language" dropdown, and user profile icons. Below the header, the "Set Home Screen" section is active, showing a note about choosing features and a search bar containing "HTMLJSPugin". A row of tabs includes Content (selected), Settings, Security, Purchase, and Analytics. The bottom section is a code editor with tabs for HTML, CSS, and JavaScript. The HTML tab is active, showing a code snippet that creates a page titled "Practice" with the heading "Finding the square root of a number". The JavaScript code includes a prompt for a number, calculates its square root using Math.sqrt(), and displays the result in an alert and on the page. To the right of the code editor is a live preview of the app, showing the rendered HTML with the heading "Finding the square root of a number" and the text "Example 1" followed by "The square root of null is 0". A "Preview" button is located below the preview area.



Mathematical manual verification

Code

```
15 //function uses IVT to calculate 0's of f
16 function calculateIVT() {
17     error_margin = document.getElementById("error_margin").value;
18     x1 = document.getElementById("x1").value;
19     x2 = document.getElementById("x2").value;
20
21     //iterate as long as error is greater than our error margin
22     iterations = 0;
23     while (true) {
24
25         //calculate f(x1) and f(x2)
26         y1 = Math.pow(x1,3) - Math.pow(x1,2) + 1;
27         y2 = Math.pow(x2,3) - Math.pow(x2,2) + 1;
28
29         //calculate midpoint and f(midpoint)
30         midpoint = (Number(x1) + Number(x2))/2;
31         ym = Math.pow(midpoint,3) - Math.pow(midpoint,2) + 1;
32
33         //assign midpoint as x1 or x2 depending on signs
34         if (y1 < 0 && ym >= 0) {
35             x2 = midpoint;
36         } else {
37             x1 = midpoint;
38         }
39
40         //calculate error and decide whether to end iteration
41         error = Math.abs(Math.abs(x2) - Math.abs(x1));
42         if (error <= error_margin) {
43             break;
44         }
45     }
```

Mathematical Verification

$$y_1 = x_1^3 - x_1^2 + 1$$

$$y_2 = x_2^3 - x_2^2 + 1$$

Calculate midpoint of the interval

Input:

$$x_m = \frac{x_1 + x_2}{2}$$

Output:

$$y_m = f(x_m) = x_m^3 - x_m^2 + 1$$

Identify any interval where $f(x)$ has opposite signs, which is the new interval

....

Solving a quadratic equation using the quadratic formula

The image shows a web development interface with a sidebar on the left containing navigation links: Dashboard, Design, Add Media, Home Screen, Features, Commerce, Notifications, Users, Analytics, Settings, and Developers. The main area is titled "Set Home Screen" and includes a search bar with "HTML5Plugin" entered. Below the search bar are tabs for Context, Settings, Security, Purchase, and Analytics. The HTML tab is active, displaying the following code:

```
1 <html>
2 <body style="background-color: powderblue;">
3
4 <h1 style="text-align: center;">Welcome to the Quadratic Formula Calculator</h1>
5 <p style="text-align: center;">This program will solve quadratic equations of the form  $ax^2+bx+c=0$ .<br>
6 Enter values a, b, and c of your quadratic equation.</p>
7
8 <center>
9 <form name="calc">
10 Value for a:<input type="text" name="a"><br><br>
11 Value for b:<input type="text" name="b"><br><br>
12 Value for c:<input type="text" name="c"><br><br>
13
14 <input type="button" name="Calculate" value="Calculate" onClick="eval()">
15
```

On the right side of the interface, there is a preview of the calculator's user interface. It has a light blue background and a red close button in the top right corner. The title "Welcome to the Quadratic Formula Calculator" is centered at the top. Below the title, a paragraph explains the program's purpose: "This program will solve quadratic equations of the form $ax^2+bx+c=0$. Enter values a, b, and c of your quadratic equation." There are three input fields labeled "Value for a:", "Value for b:", and "Value for c:". Below these fields are two buttons: "Calculate" and "Clear". At the bottom, there are two output fields labeled "Solution 1:" and "Solution 2:". A "Preview" button is located at the bottom right of the interface.

Find the determinant of a square matrix



The image shows a mobile app development interface. On the left is a sidebar menu with options: Dashboard, Design, Add Media, Home Screen, Features, Commerce, Notifications, Users, Analytics, Settings, and a Download button. The main area is divided into two panels. The left panel, titled "Set Home Screen", shows a preview of the app's home screen with a blue header, a search bar, and a list of features. Below this is a code editor showing HTML, CSS, and JavaScript code for the app. The right panel shows a preview of the "Determinant Matrix Calculator (3x3)" app. It has a blue background and contains the following text: "For this program you can calculate the determinant of a square (3x3) matrix. Please enter the values of your matrix below." Below the text is a 3x3 grid of input fields. At the bottom of the grid are two buttons labeled "Calculate" and "Clear". Below the buttons is a label "Determinant" followed by a text input field. At the very bottom of the right panel is a "Preview" button.

Math+ Biology



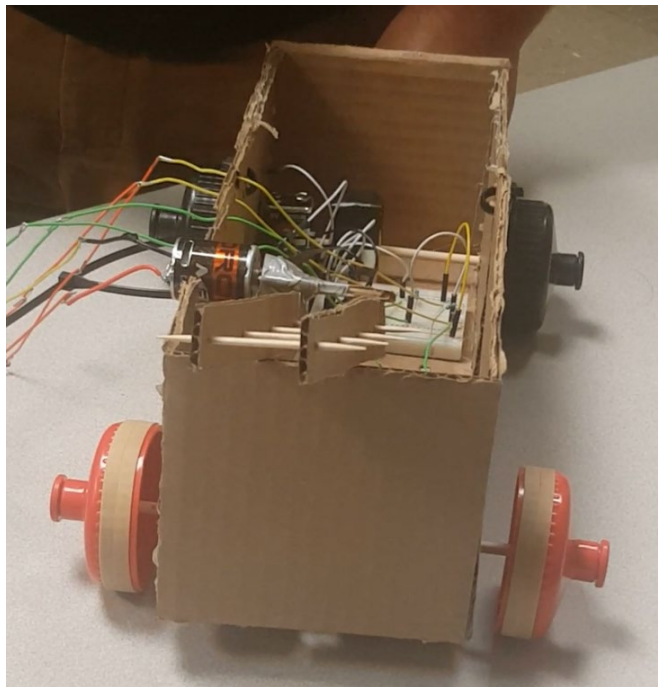
Growing Kefir



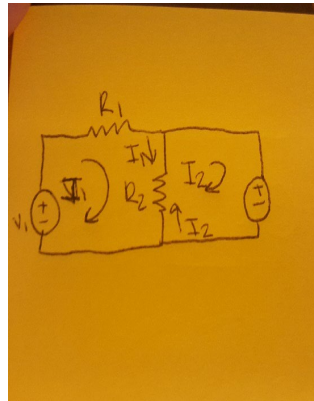
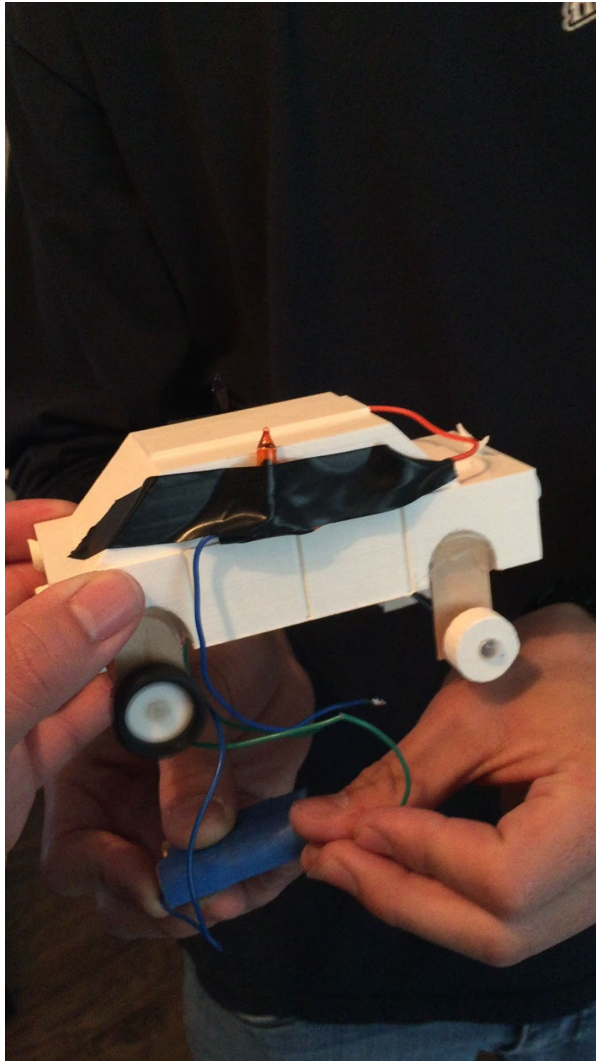
Math+ Engineering/Physics



Designing Toy Car



Math+ Engineering/Physics



$$\begin{cases} I_1 R_1 + (I_1 - I_2) R_2 = V_1 \\ I_2 R_2 = V_2 \end{cases}$$

$R_1 = 0.4$
 $R_2 = 0.7$
 $V_1 = 3$
 $V_2 = 3$

$$\frac{I_2(0.7) = 3}{0.7} \Rightarrow I_2 = 4.286$$

$$I_1(0.4) + (I_1 - 4.286)0.7 = 3$$

$$I_1(0.4) + I_1 - 4.286(0.7) = 3$$

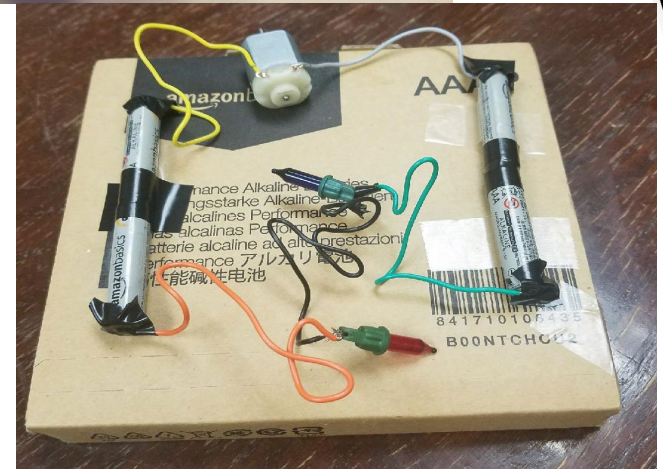
$$I_1(0.4) + I_1 - 3.002 = 3$$

$$+ 3.002 + 6.002$$

$$\frac{\Delta I_1(0.4) = 6.002}{2} \Rightarrow I_1(0.4) = 3.001$$

$$\frac{3.001}{0.4} \Rightarrow I_1 = 7.5025$$

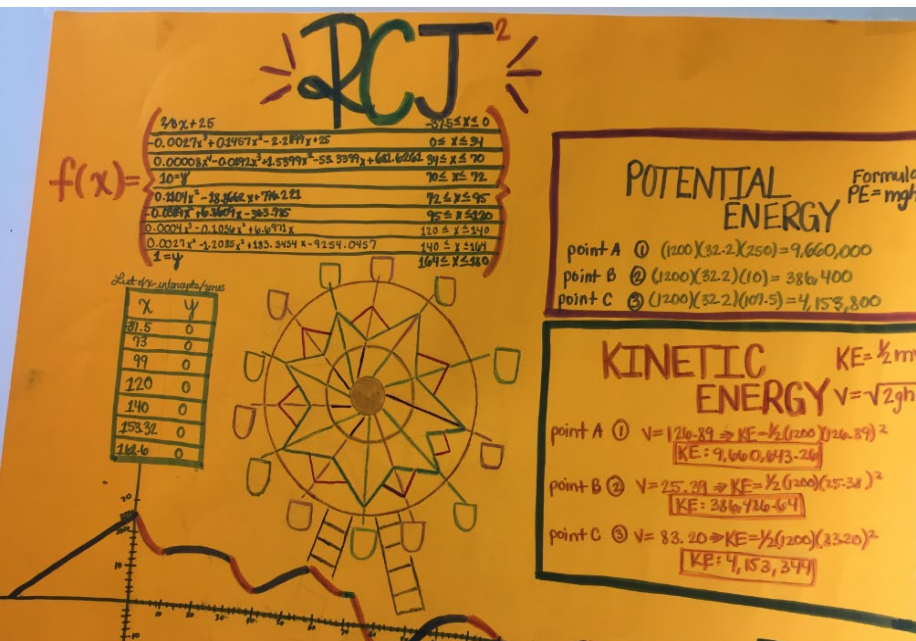
(7.5025, 4.286)



Math+ Engineering/Physics

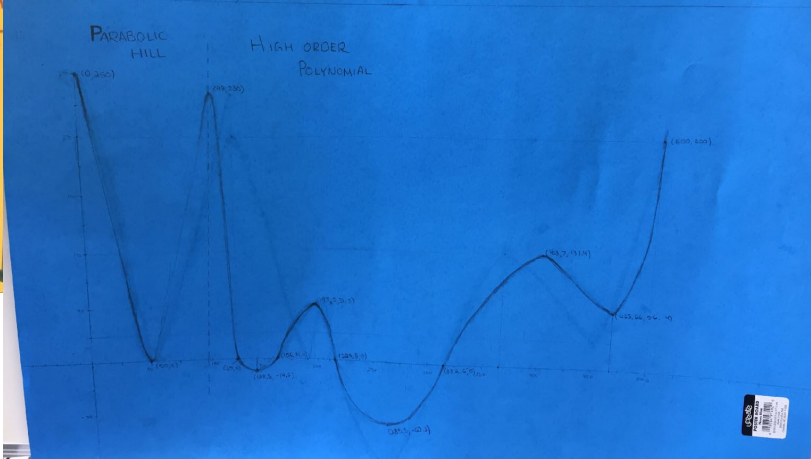


Designing Roller Coaster

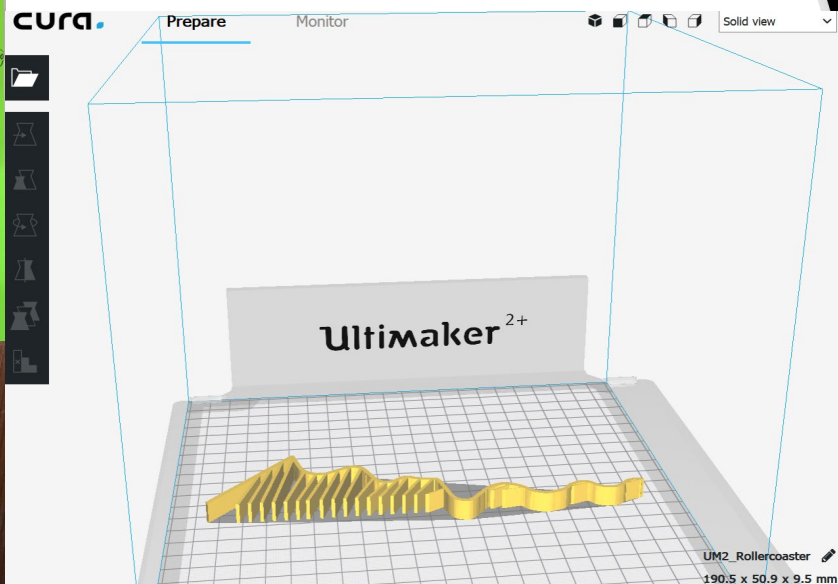
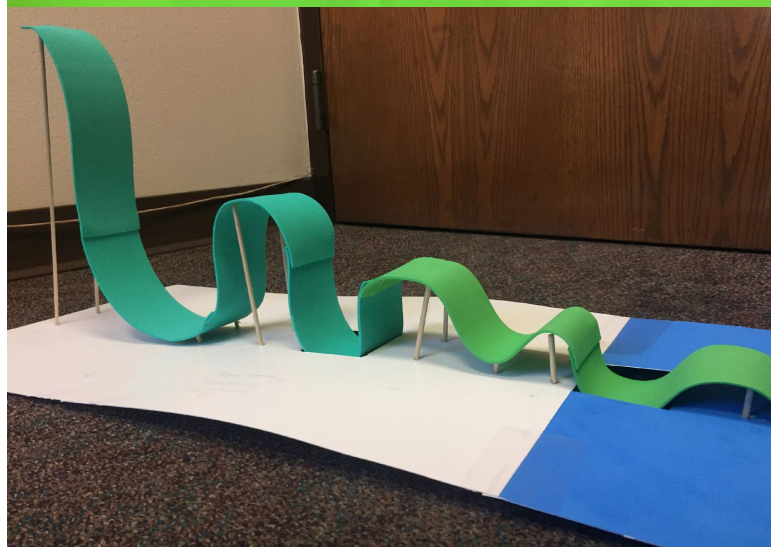
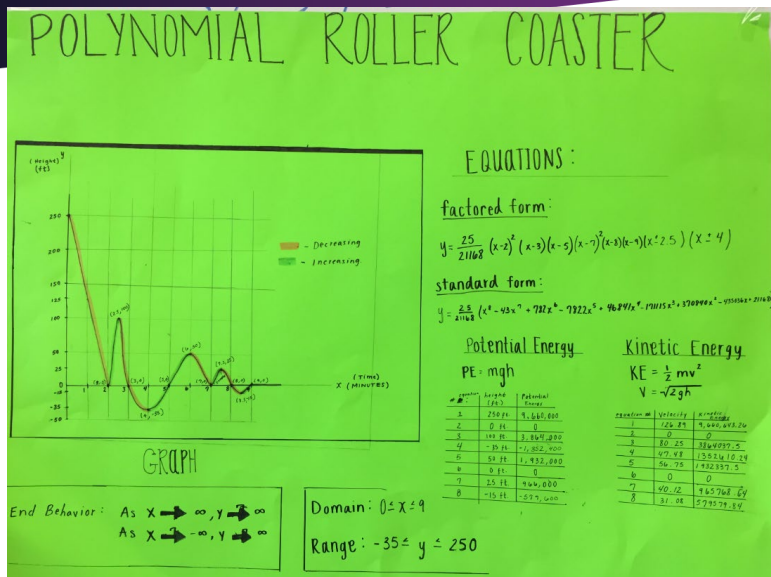


REVERSE PSYCHOLOGY

Point	Height (ft)	Velocity (ft/s)	Potential Energy (J)	Kinetic Energy (J)	Total Energy (J)
1	250	126.89	9,660,000	9,660,000	19,320,000
2	10	25.29	386,400	386,400	772,800
3	101.5	83.20	4,153,800	4,153,800	8,307,600



Math+ Engineering/Physics





Math+ Engineering

Designing A Bridge



Our Challenging Problem

How do we, as college math instructors, provide the most effective environment for teaching and learning using project based learning methodology, **so that** students acquire the knowledge, skills, and interests for success in college and career?



Q&A



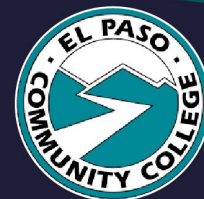
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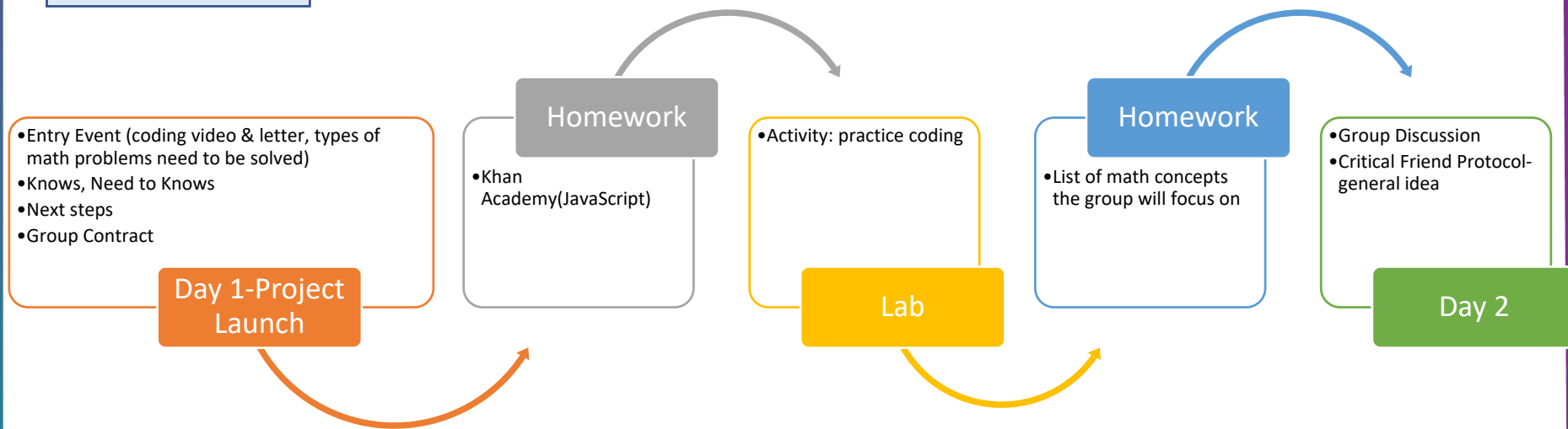


Back up slide

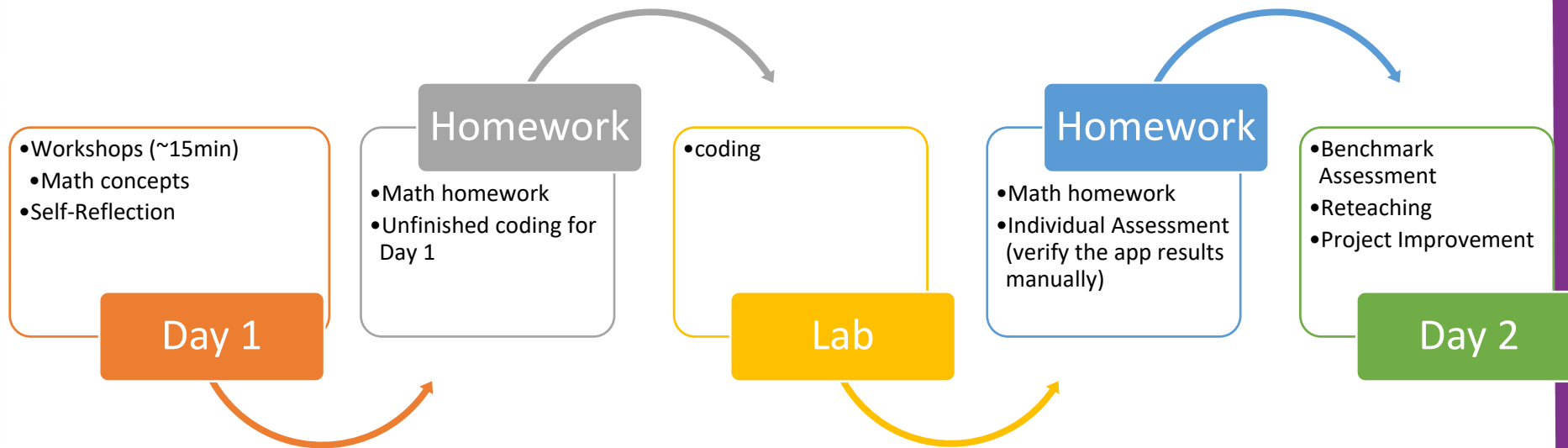


Project Timeline (4 weeks)

Week 1



Week 2, 3



Week 4

