



Graspable Math

Canvas User Guide

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TABLE OF CONTENTS

GRASPABLE MATH (GM) CANVAS

[Introduction](#)

[Opening the Canvas in graspablemath.com](#)

[Making an Account](#)

[Adding to GM Canvas](#)

[Adding an Expression](#)

[Adding a Graph](#)

[Adding Text](#)

[Insert Image/Video](#)

[Insert Function](#)

[GM Canvas Tools](#)

[Transform Mode](#)

[Scrubbing](#)

[Arranging](#)

[Keypad Mode](#)

[Drawing Mode](#)

[Tracing Terms](#)

[Saving the Canvas](#)

[Loading the Canvas](#)

[Sharing the Canvas](#)

[Settings on the Canvas](#)

[Document Settings](#)

[Frequently Used Gestures](#)



GRASPABLE MATH CANVAS

Introduction

Graspable Math (GM) is a research-backed dynamic algebra notation tool that allows students to physically move algebraic terms around the screen as if they were literal objects. By dragging the mouse and performing certain gestures, teachers and students can manipulate algebraic expressions and observe an immediate response to their actions.

GM is designed so that symbolically permissible moves transform an expression or equation into a new equivalent state, while impermissible moves do not. When an illegal action is attempted, the system responds with immediate feedback (e.g., terms shake or snap back into the initial position). By embedding the rules of algebra and providing instantaneous feedback so that students know exactly what moves are mathematically correct and incorrect, GM encourages students to explore and 'play' with the structure of algebra in every move.

Our Story

Math is beautiful and tremendously powerful in the hands of experts. On the other hand, to novices, math is frustrating and HARD.... all those rules to memorize, all those steps to write and keep track of.

In a world where technology has advanced at astonishing rates, the technology of math notation hasn't really changed in 400 years. The easiest way to write and solve an equation is still by hand, on paper.

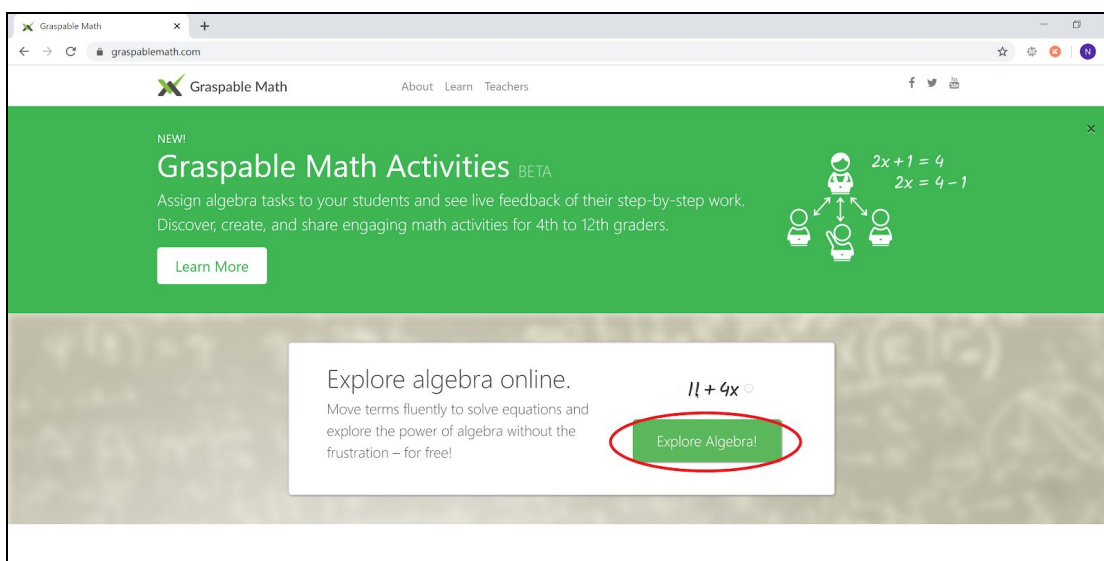
For a few years, a group of us - math educators, psychologists, mathematicians, and computer scientists - have been imagining ways to reconstruct the idea of formal notation by using digital technology. We think it's time to apply modern design approaches to build more intuitive and fluid interfaces for math. We want tools that scaffold experiences of algebraic structure, supports genuine inquiry about how math works, and gives people opportunities to reason flexibly about mathematics.



Opening Canvas on graspablemath.com

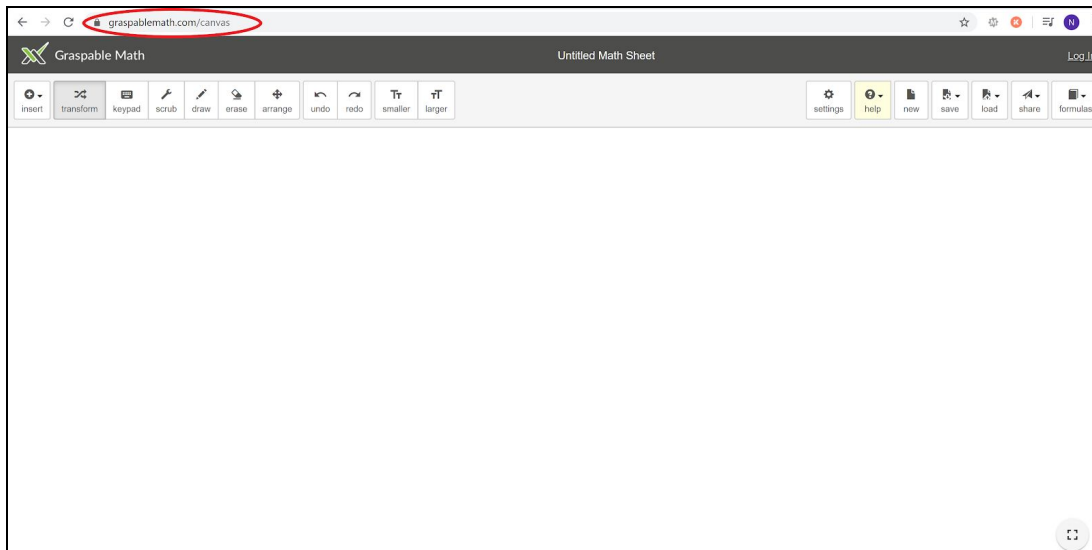
Canvas

The Canvas is a tool created by the GM team that allows users to create and manipulate expressions, graphs, and equations.



Select “Explore Algebra!”

1. Once you’ve selected the “Explore Algebra!” option, the GM Canvas will open. Another way to arrive at the Canvas is to type <https://graspablemath.com/canvas> into your URL.

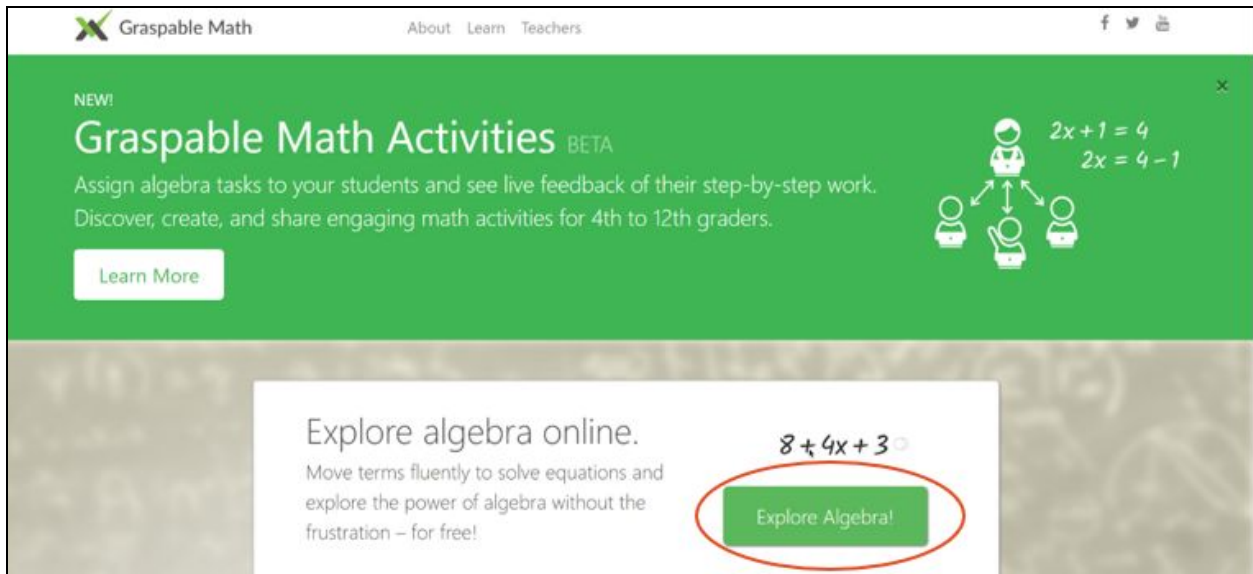


Making an Account

Signing in as a Teacher on Graspable Math (GM)

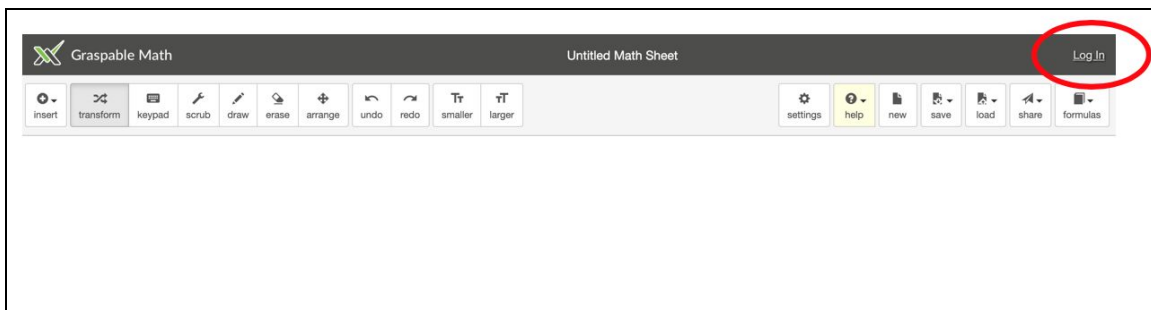
Graspable Math (GM) is a great tool for educators that allows for creating math activities that students can explore and learn math concepts and procedures in real-time. Certain features in GM, such as saving or sharing your work, require creating an account. This can be done by following the steps below.

1. Go to <https://graspablemath.com/> and click on the box labeled **“Explore Algebra!”**.



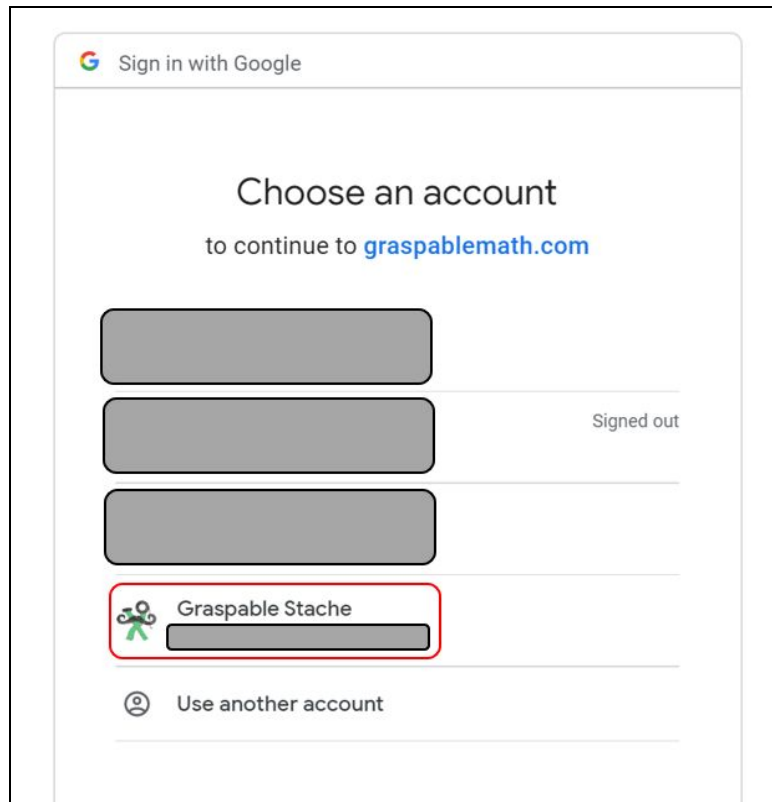
2. The GM Canvas page will open.

Click on the “**Log In**” button on the top right corner of the webpage. After clicking on the button, it will prompt you to sign in with a Google account.



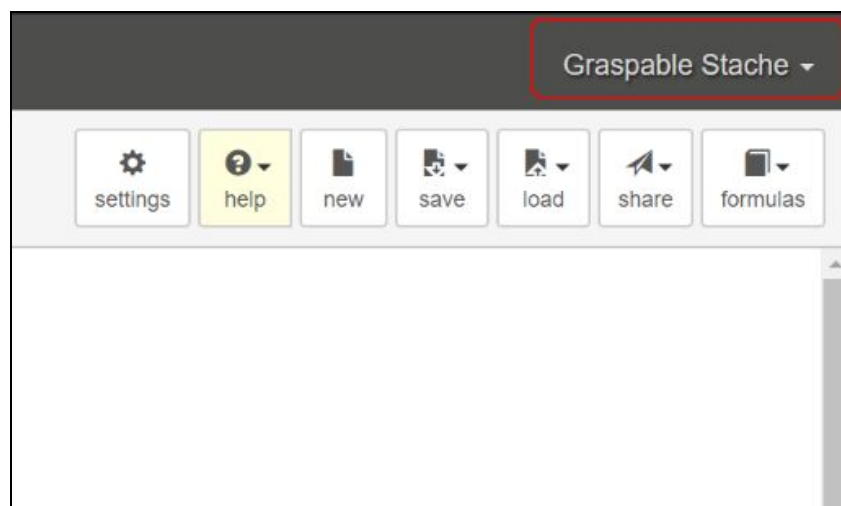
3. Next, click on the Google account that you would like to **sign up / log in** with on GM.

Note, this email will be associated with all of the content and activities that you develop on Graspable Math’s platform.



4. Once you are signed in, you will be able to see your email name on the top right corner where the “**Log In**” button used to be.

Now you are officially signed in / logged in!



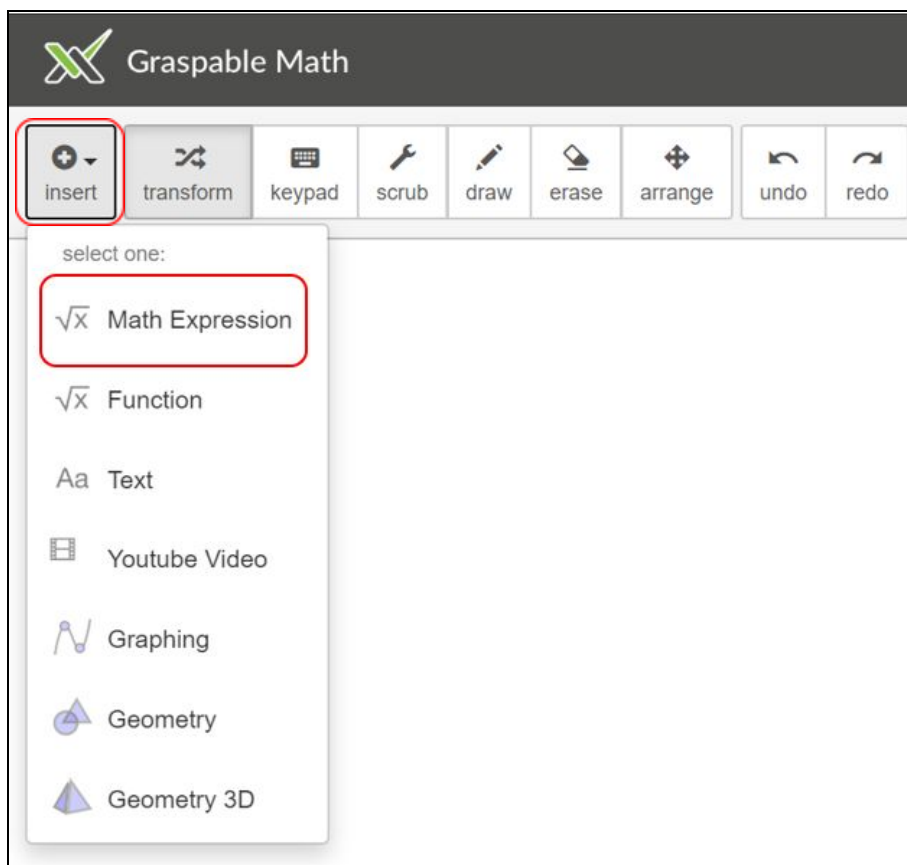


ADDING TO GM CANVAS

Adding an Expression

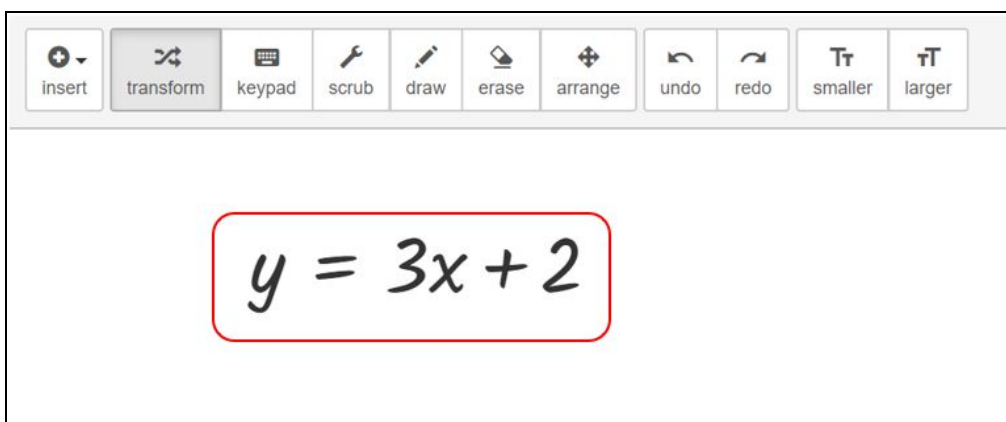
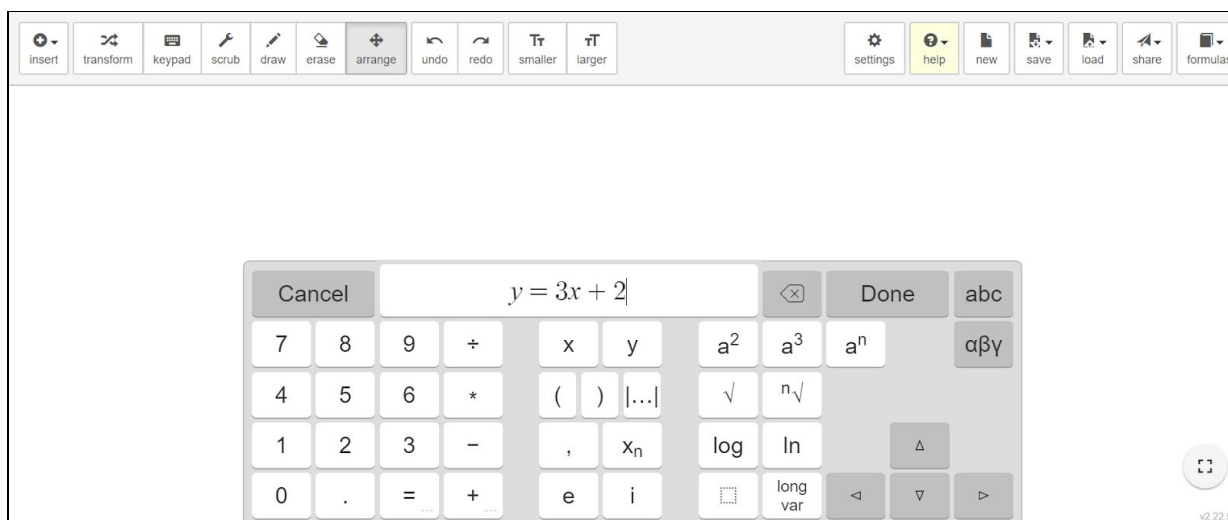
On GM Canvas, users can insert interactive math expressions.

1. To insert a math expression on Canvas, select the **“Insert”** button on the top left of the Canvas page. After clicking in this icon, a dropdown menu will appear, listing multiple things that you can insert into the Canvas, including math expressions, functions, videos and graphs.
2. Select **“Math Expression”** to insert a math equation or expression.





3. After selecting **"Math Expression"**, you will see a keyboard at the bottom of the screen. You can create a math expression or equation either by clicking on numbers and symbols on the keypad or by typing in your desired expression.
4. Select **"Done"** when you are finished, and the expression you created will appear on your Canvas.

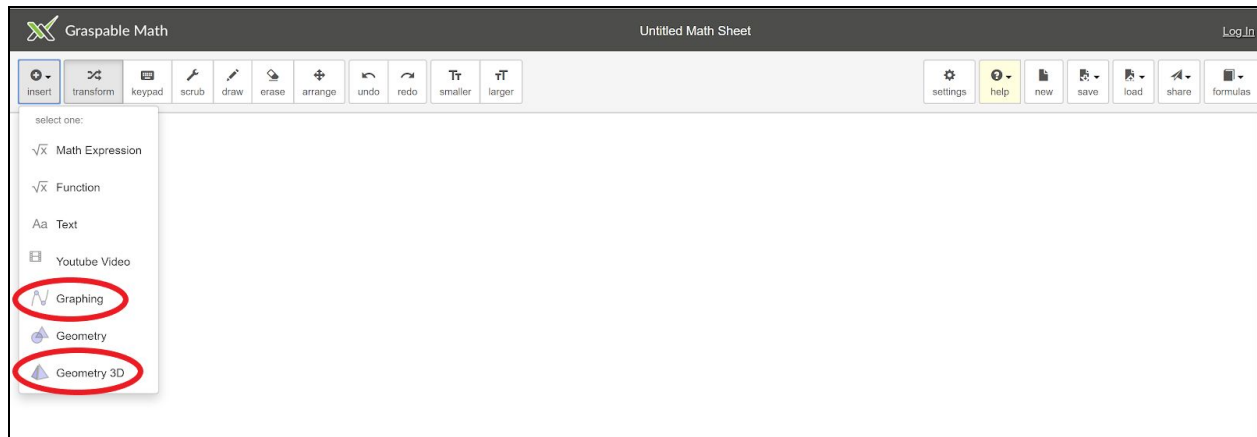


Adding a Graph

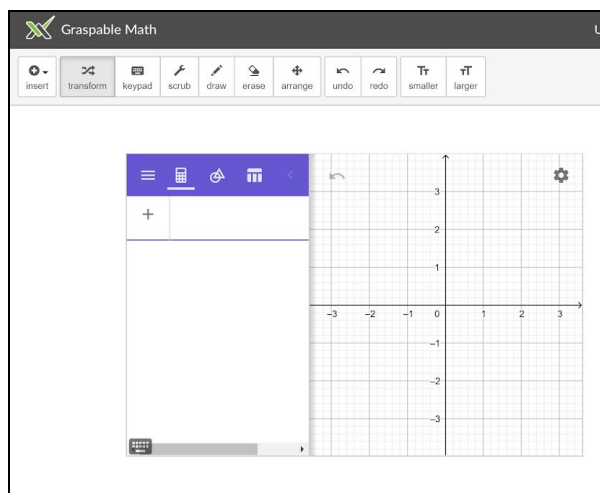
The Graspable Math Canvas allows you to insert graphs, 2D, and 3D geometry through embedding GeoGebra elements. To insert a graph follow these steps. You can find more instructions on how to use GeoGebra on their [website](https://www.geogebra.org/m).



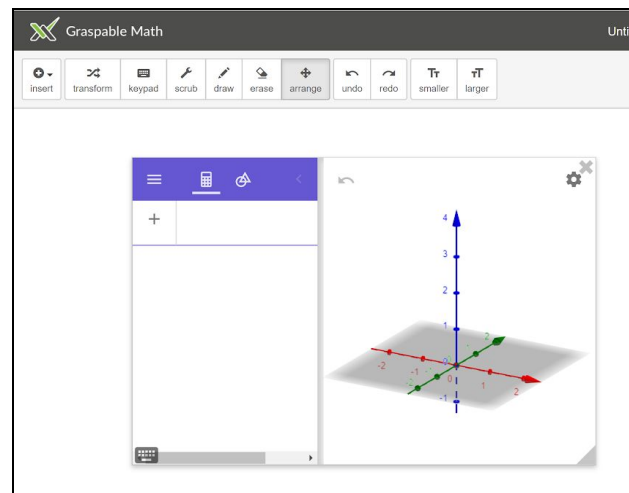
- To add a graph, select the **“Insert”** button on the top left corner of the page.
 - Select the **“Graphing”** option to add a **two-dimensional** graphing window,
 - Select the **“Geometry 3D”** option to create **three-dimensional** graphs.



2D Graph (Graphing)



3D Graph (Geometry 3D)

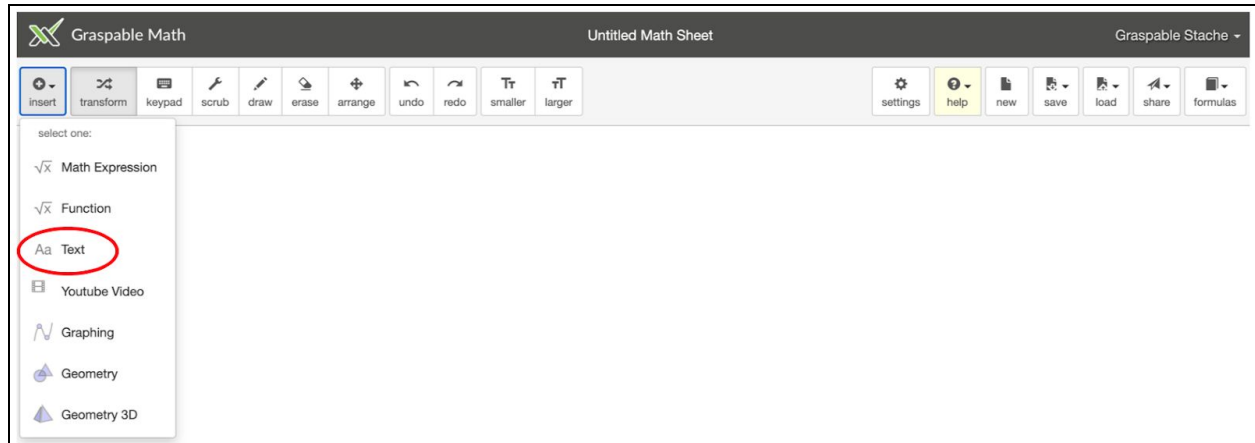


Adding Text

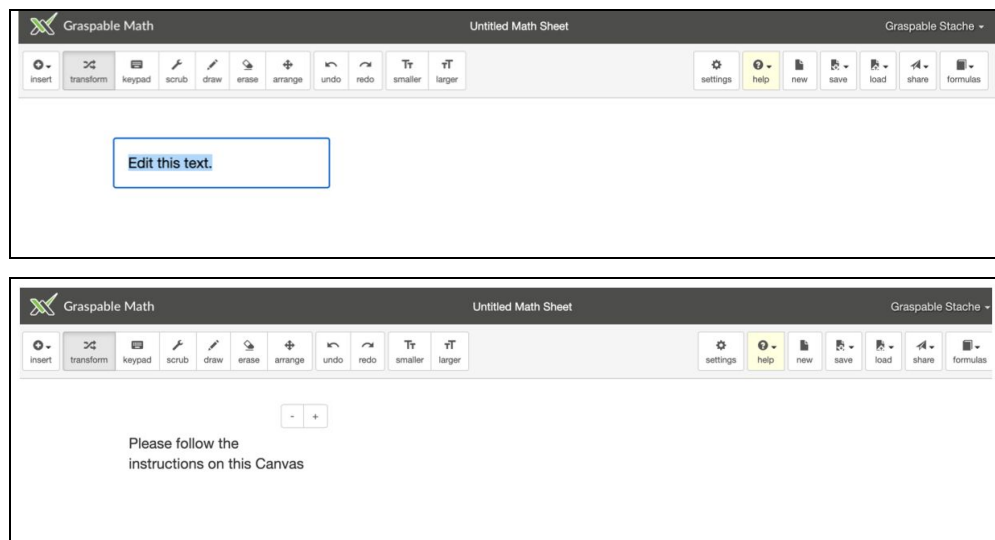
Adding text on a GM Canvas is how you can provide direction and instructions to your students regarding the assigned task.



1. To insert text on your Canvas, click on **“Insert”** then select **“Text”** from the dropdown menu.



2. A text box will appear on your Canvas with the line “Edit this text”. Click on the text box and type in text to create any instructions or direction for your students.



3. You can increase or decrease the size of your text by clicking on the **“-/+”** button on the upper left corner of the text box.

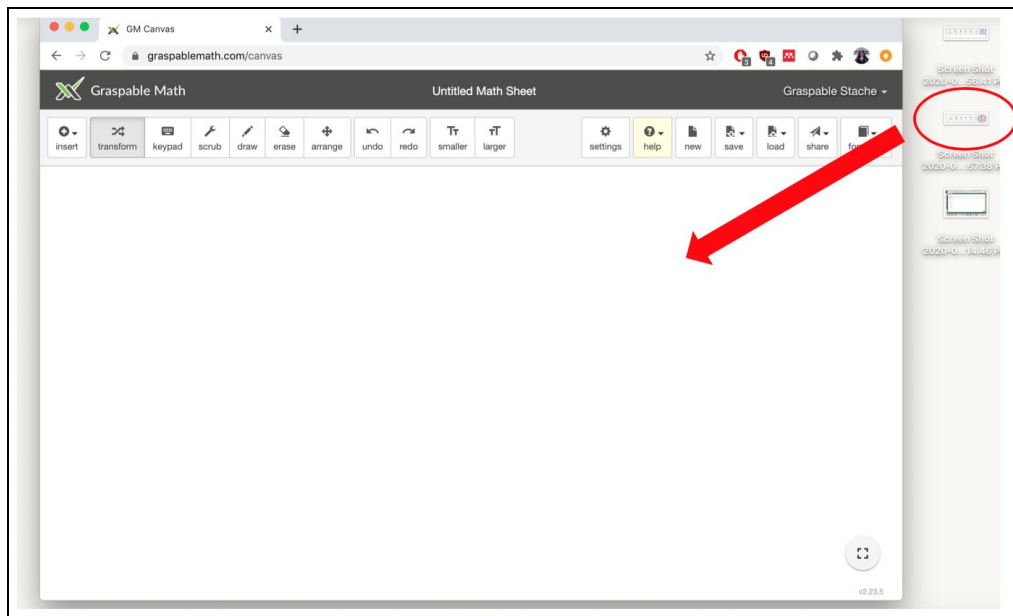


Insert Image/Video

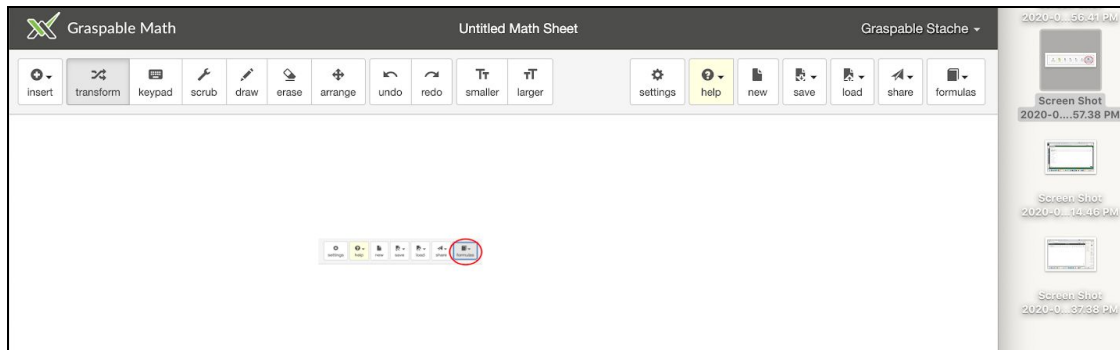
Inserting an Image or GIF

All images or GIFs that you would like to add to your Canvas page must be downloaded onto your computer.

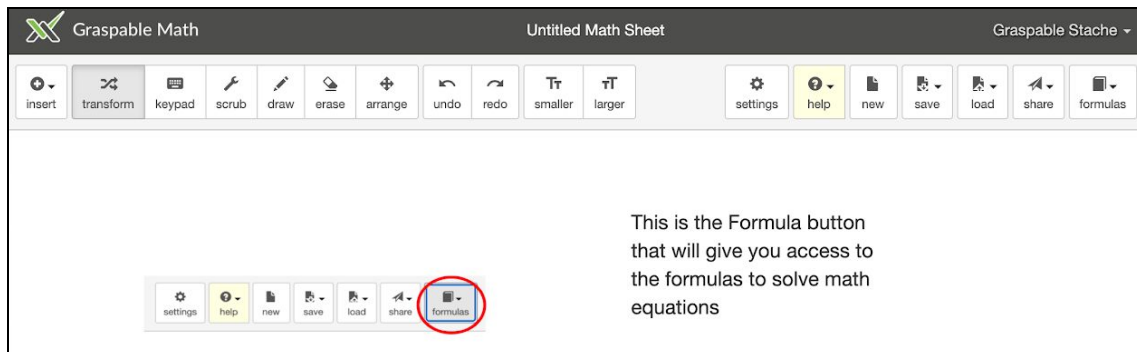
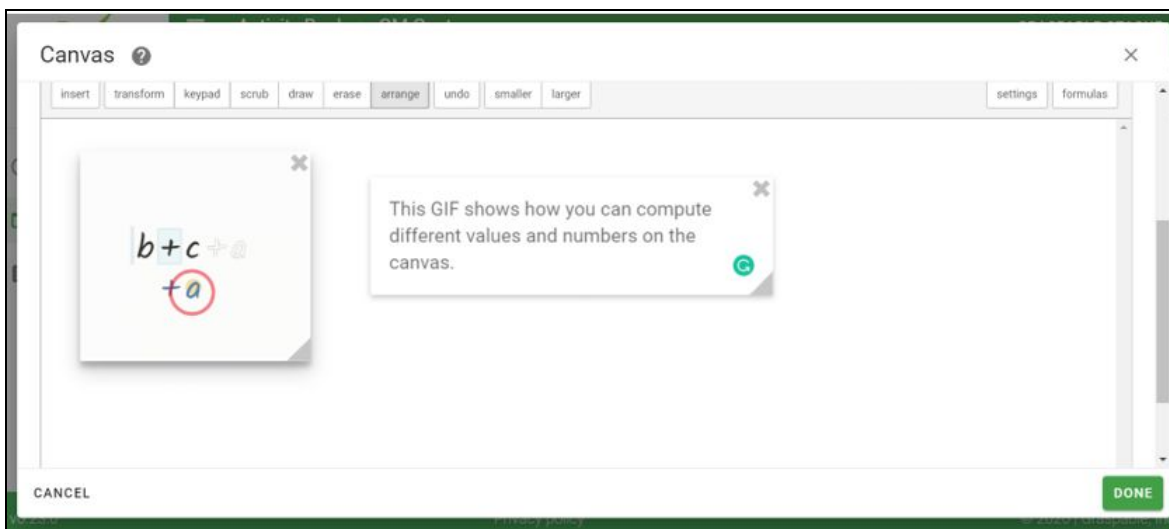
1. While having your Canvas open, open your file folder containing the image/gif you'd like to insert. You add images/gifs onto your Canvas by dragging them from their folder on your computer onto the Canvas page.



2. When you see your image/gif displayed on your Canvas, that means it is successfully uploaded.



- Once your file has been uploaded, you can arrange or resize it to fit your needs. You can also place text, math equations, graphs,... next to the image for description or instruction.



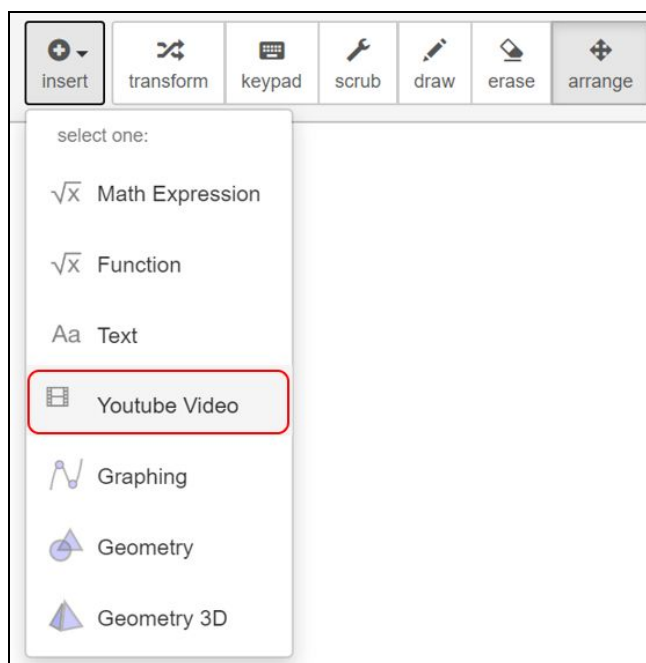


Inserting a Youtube Video onto the GM Canvas

At the time being, Canvas only allows Youtube videos to be published onto the Canvas. We strongly encourage teachers to create their own videos to best tailor the needs of their students. Videos that are not publicly available on Youtube can still be posted on the canvas page.

Please feel free to visit our official [GM Youtube channel](#) and the [Graspable Stache](#) channel for videos and resources on GMA content, instructions, and gestures!

1. To insert a video on the Canvas, locate the **“Insert”** button on the top-right of the canvas, then select **“Youtube Video”** in the dropdown menu.



2. The **“Youtube Video ID”** window will appear.



The screenshot shows a web interface for Graspable Math. At the top is a toolbar with icons and labels: 'insert', 'transform' (highlighted), 'keypad', 'scrub', 'draw', 'erase', 'arrange', 'undo', 'redo', 'smaller', and 'larger'. Below the toolbar is a large rectangular canvas. Inside the canvas is a smaller white box with a red border. This box contains a form for embedding a YouTube video. The form has the title 'Youtube Video ID' above a text input field. Below this is a 'time range' section with 'from' and 'to' input fields. At the bottom of the form is a 'Load' button.

3. To link your video, you will need to insert the link from your video in the first box underneath **"Youtube Video ID"**. Optionally, you can provide a start and end time for the part of the video you want to play.

To obtain your youtube videos link, click **"share"** on the button on Youtube. Then click **"copy"** on the right side of the link.



Graspable Math Algebra Notation

1,457 views • Mar 30, 2020

21 0 SHARE SAVE ...

Share

Embed Facebook Twitter Blogger reddit Tumblr

<https://youtu.be/DATXmqvFI4w> COPY

☐ Start at 0:05

Here is an example of how to fill out the “**Youtube Video ID Window**”.



Youtube Video ID

https://youtu.be/DATXmqvFI4i

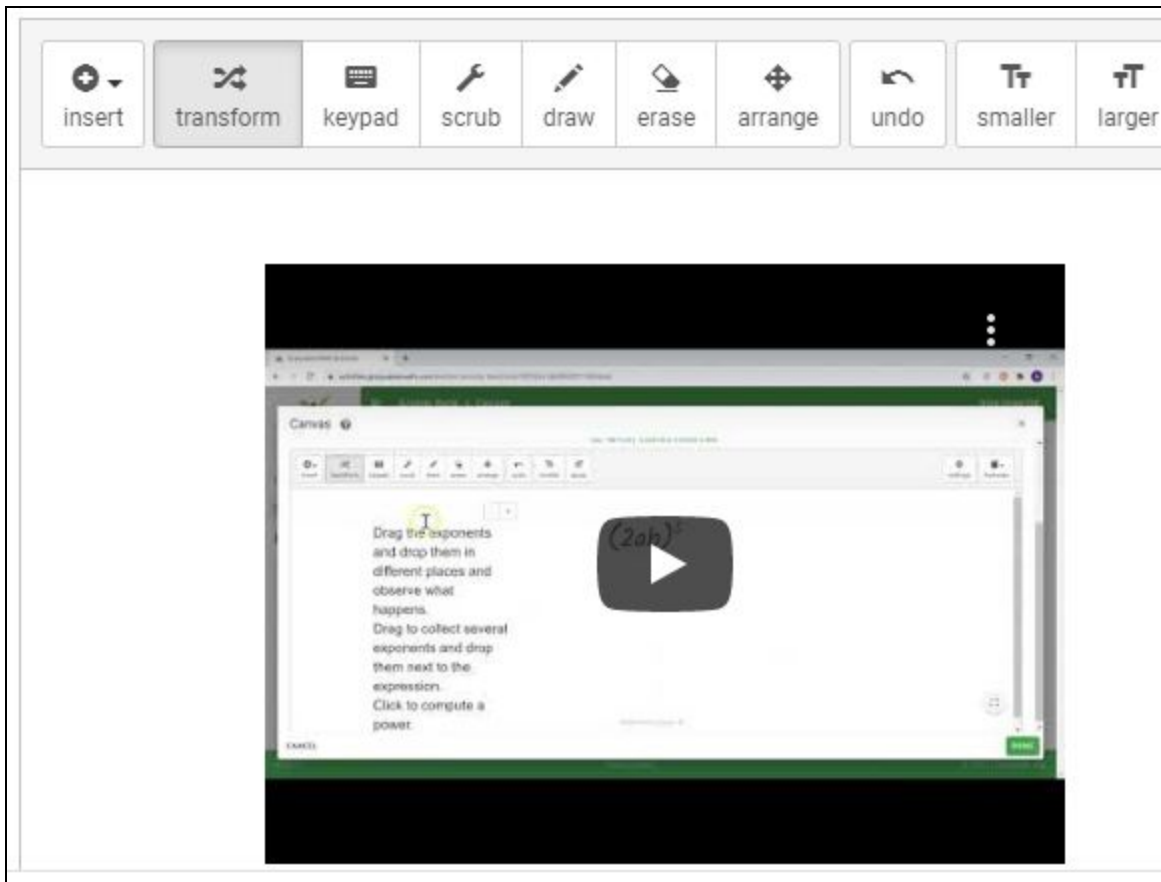
time range

0:00

5:35

Load

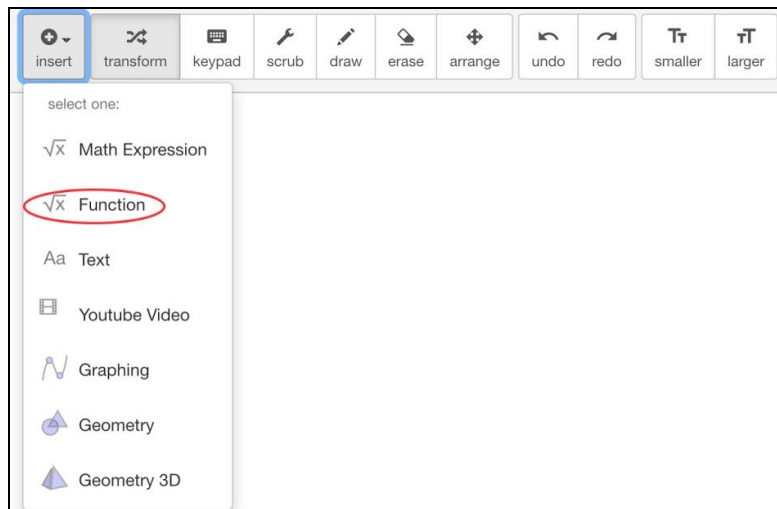
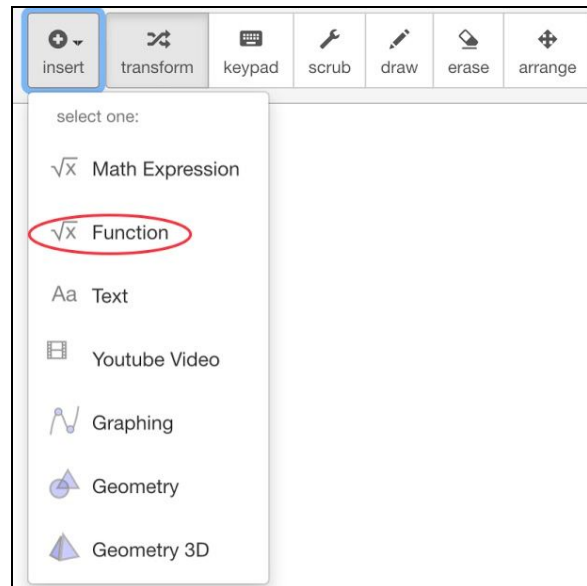
- Click **"Load"** to complete add the video to the page. Here is the complete result.



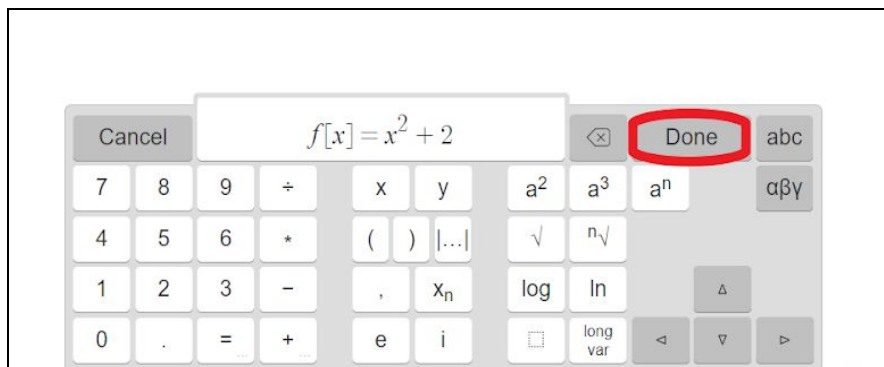
Insert Function

Functions are an integral part of mathematics, and Canvas allows you to manipulate every part of a function and give your students a deeper understanding of the inner workings of mathematical properties. The insert function action is identical to the insert math expression action, except that it prefills the keyboard with the " $f[x]=x$ ", which you can then adjust. Graspable Math uses square brackets for function arguments to distinguish between "function f of x ", $f[x]$, and "variable f times in-brackets x ", $f(x)$.

1. Select the **"Insert"** button on the toolbar, then in the dropdown menu, select **"Function"**.



2. A keypad will pop up with the text " $f[x] = x$ ". You can replace the " x " after the equal sign with your desired function. Select "**Done**" when you're done.

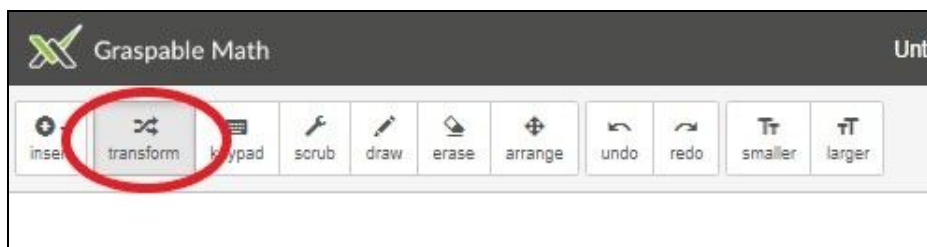


GM CANVAS TOOLS

Transform Mode

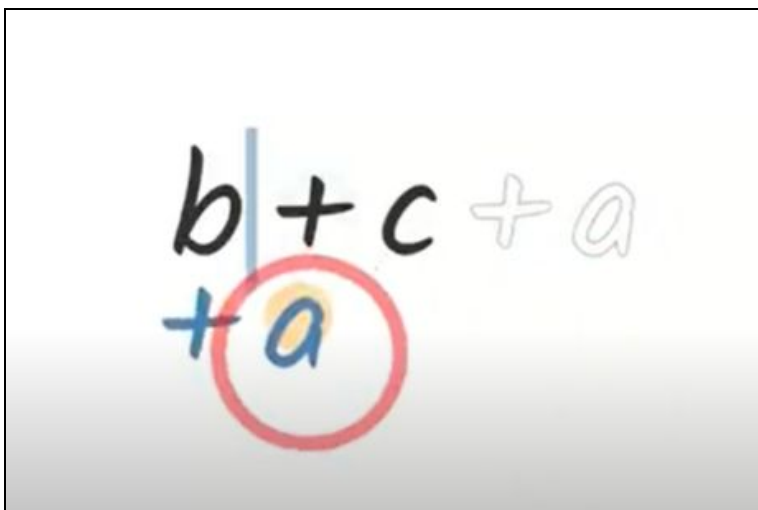
The Transform mode in Canvas is a critical function to know! This mode allows you and your students to manipulate equations and expressions. In this mode, you can also show the history of a solution or copy an equation.

1. To use this mode, select the **“Transform”** button on the top left corner of the toolbar.



Solving Equations

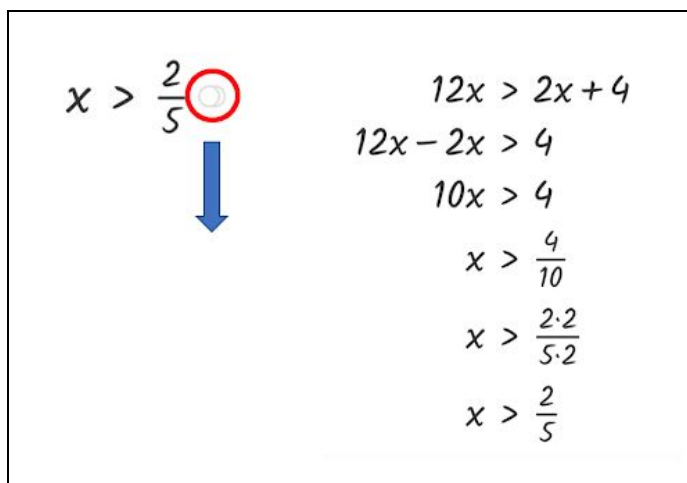
In Transform mode, you can click and drag terms in order to solve math equations.



You'll find a list of frequently used GM gestures at the end of this document.

Showing History

After you solved a math equation on Canvas, you can see the history of all of your transformations by dragging down the circle next to your final equation.



If there are two stacked circles shown next to an equation, that means there are more steps that can be shown.



$$\begin{array}{l}
 12x > 2x + 4 \quad \circ \\
 6x > x + \frac{4}{2} \quad \circ \\
 6x > x + 2 \quad \circ \\
 6x - x > 2 \quad \circ \\
 5x > 2 \quad \circ \\
 x > \frac{2}{5} \quad \circ
 \end{array}$$

Replicating An Equation

In order to copy an equation, drag the circle next to the equation to the area of the canvas you would want to place the copy.

$12x > 2x + 4 \quad \circ$

$12x > 2x + 4$

$12x > 2x + 4$



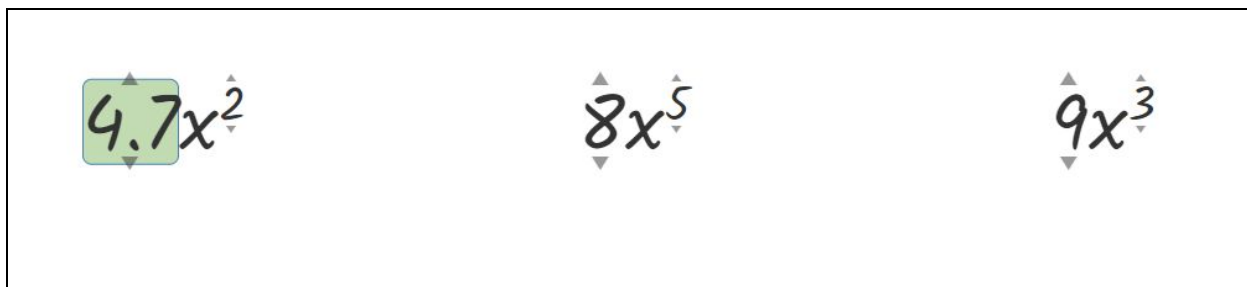
Scrubbing

Scrubbing is a tool that allows you or your students to change the value of any number in the Canvas by clicking and dragging a number up or down. Scrubbing is especially useful to explore how a solution works for different numerical values in the initial expression.

1. To scrub any number, select the **“Scrub”** button on the tool tab, then a pair of arrows will appear on top and under any number that can be scrubbed.



2. To increase the value, click on the number you wish to change, hold and scroll up.



3. To decrease the value, click on the number you wish to change, hold and scroll down.



$$4x^2$$

$$8x^5$$

$$9x^3$$

$$2.7x^2 \circ$$

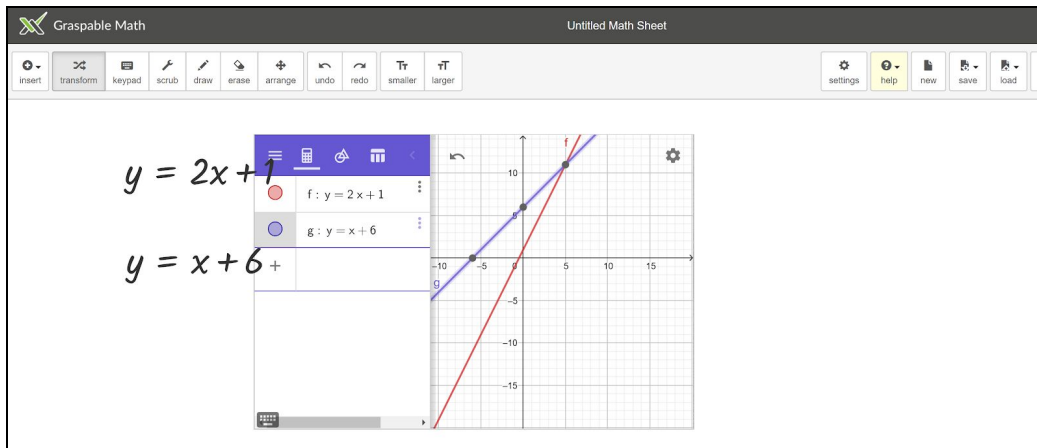
$$8x^5$$

$$9x^3$$

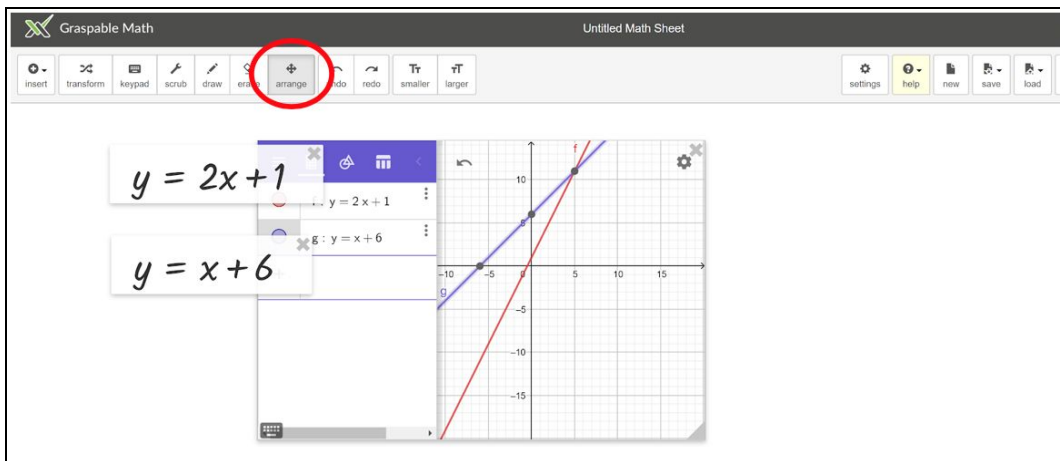
Arranging

The “**Arrange**” tool will help you organize your work on Canvas. You can use this tool to **arrange or delete** the content on your Canvas.

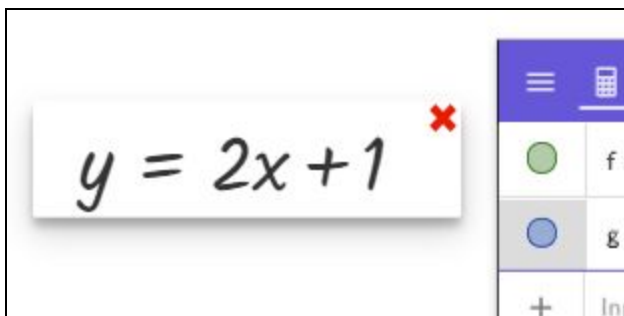
For instance, the Canvas below has overlapping content (equations on top of graph), which makes it bothersome for users to see and navigate.



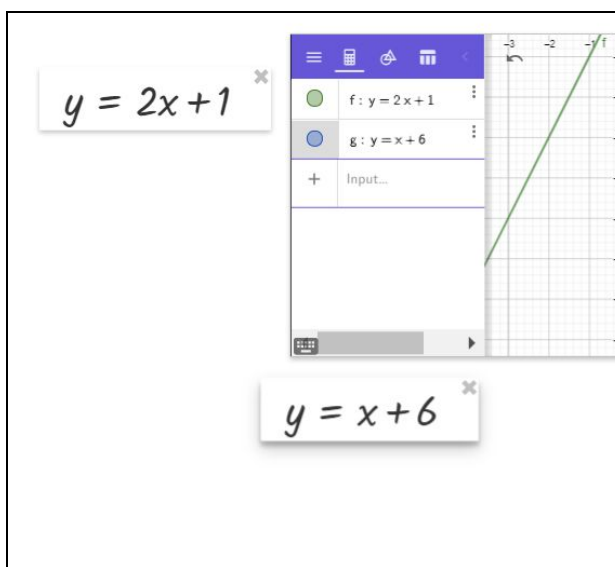
1. Select the “**Arrange**” tool in the middle of the tool bar. All pieces of content you’ve created on Canvas will be displayed in boxes, which can be moved or deleted.



2. To delete a piece of content, hover over the box of content you wish to delete, and click on the **x** on the top right of the box.



3. In order to move and organize objects, click and drag on the desired box of content.



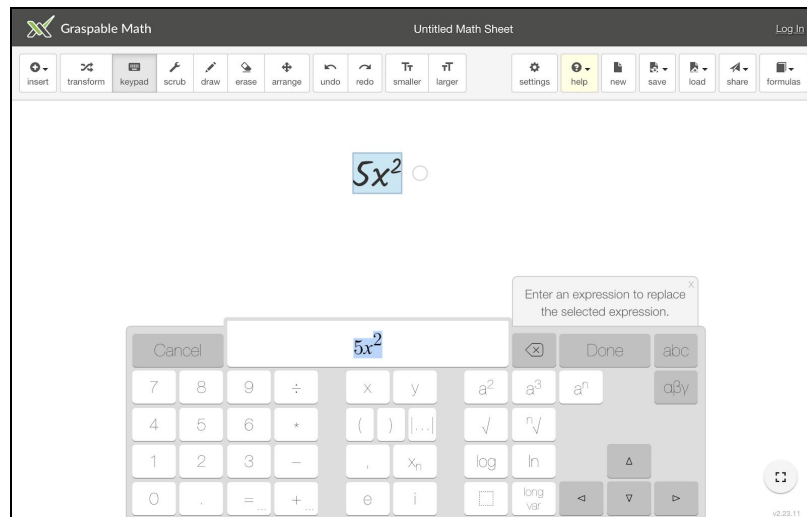
Keypad Mode

The keypad allows you to modify existing math expressions. In keypad mode, you can click on any expression and use the keyboard to replace it with any other expression. This is great for situation where you want to split up a term, such as replace 12 with $3 \cdot 4$, or when you want to factor quadratics. Graspable Math will warn you when you attempt to replace an expression with a non-equivalent expression.

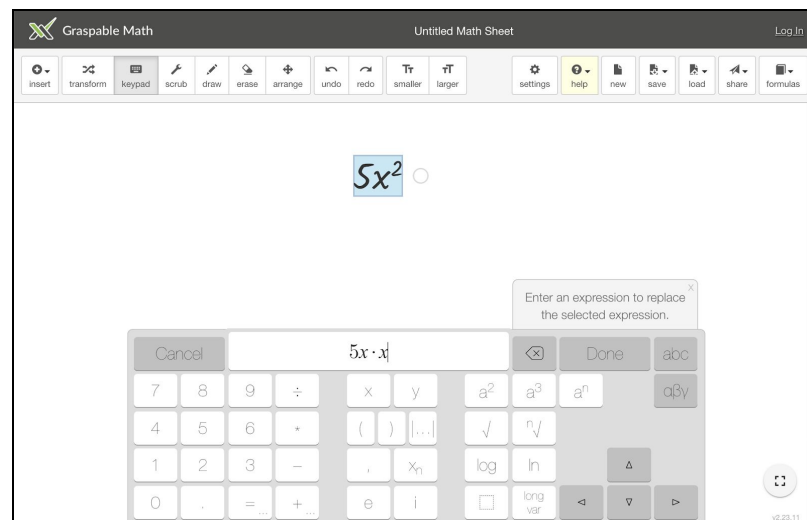
Changing a term using the keypad

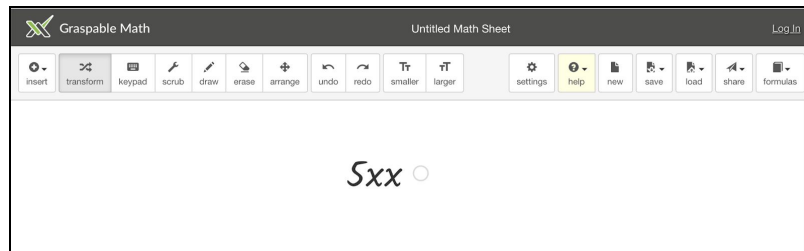


1. Select the “**Keyboard**” button on the top left of the page, then select the term you want to modify.



2. On the keypad, type in the new term you want to replace, and click “**Done**”. The old term will be modified into your desired new term.

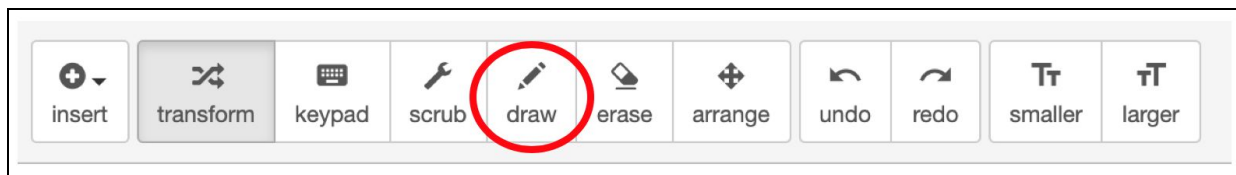




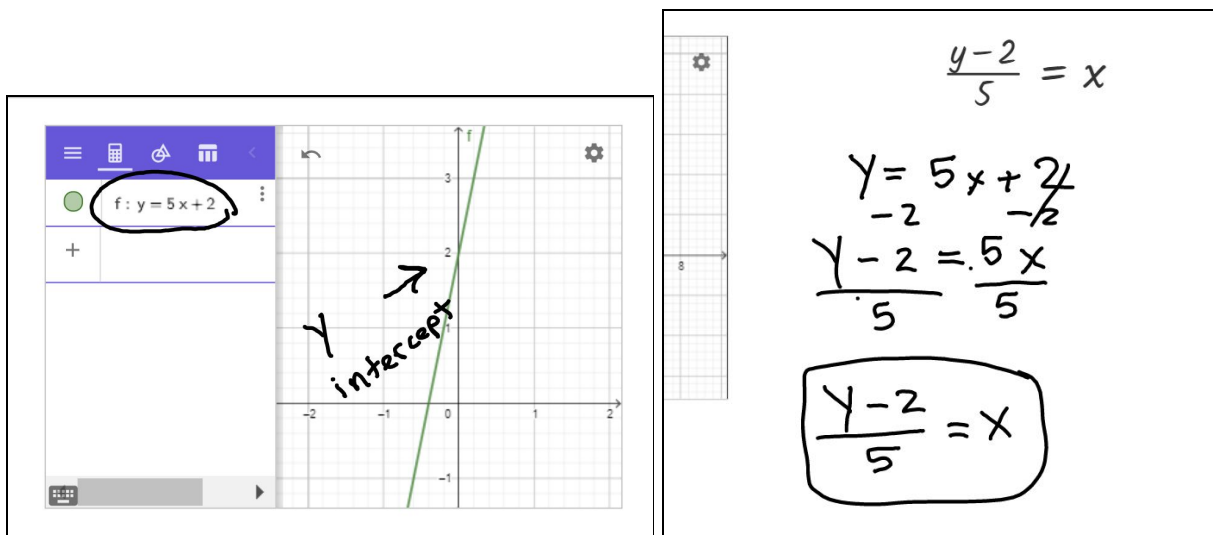
Drawing Mode

The drawing mode is a useful tool for working out problems by hand, as well as highlighting and annotating materials.

1. In order to draw on Canvas, select the “**Draw**” button on the toolbar.



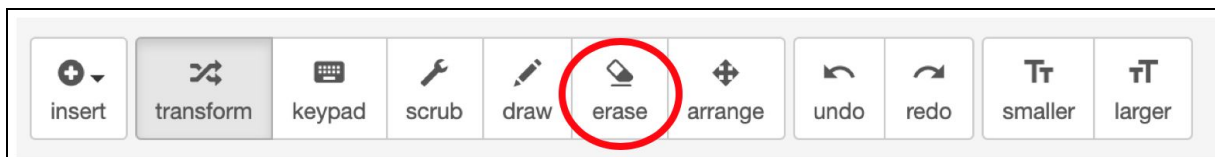
2. Click and drag the mouse or use a stylus to draw on the Canvas. Any materials on Canvas can be drawn on, including graphs, pictures and videos.



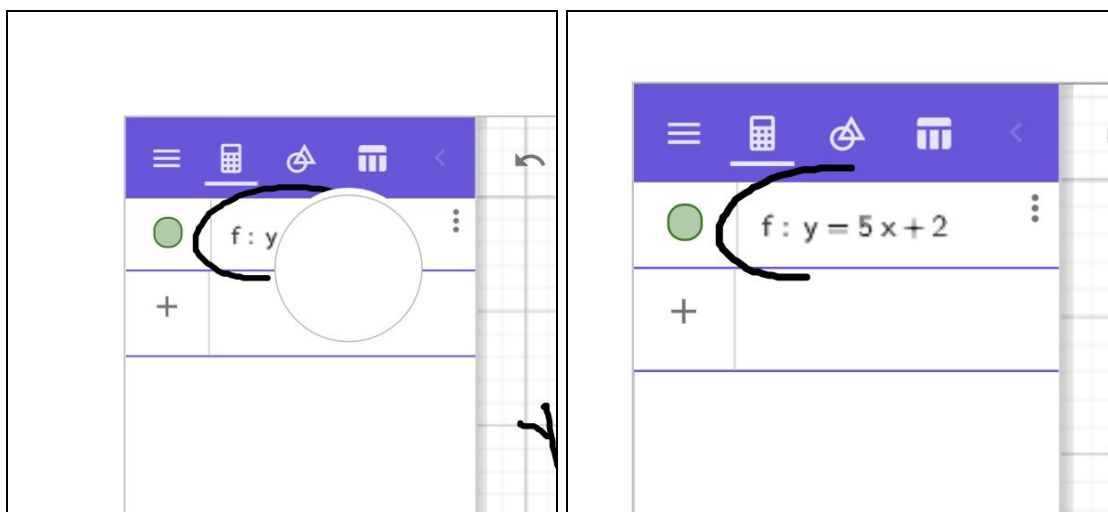


How To Erase

1. To erase your drawing on the Canvas, select the “**Erase**” button next to the drawing button.



2. A white circle will appear that will erase anything it hovers over. Drag the circle around to erase on Canvas.



Tracing Terms

Canvas and GM allows users to trace terms within a transformation; in other words, users can select a mathematical term and see “where it came from” and “what happens to it next” in a derivation. Tracing terms is helpful to show students how a term was transformed within an equation.

1. To trace a term, first you will need to show the history of the transformed equation.



$$\begin{array}{rcl}
 x = 2 & & 8x + 6 = 22 \\
 \downarrow & & 8x = 22 - 6 \\
 & & 8x = 16 \\
 & & x = \frac{16}{8} \\
 & & x = 2
 \end{array}$$

2. Select the “**Scrub**” button on the toolbar, then click on the term that you would like to trace. In our example below, we choose to trace the answer “2”. A green path will appear, showing how the term was transformed throughout the equation, and what other terms were used within the transformation.

Toolbar: insert, transform, keypad, **scrub**, draw, erase, arrange, undo, redo, smaller, larger

$$\begin{array}{rcl}
 8x + 6 & = & 22 \\
 8x & = & 22 - 6 \\
 8x & = & 16 \\
 x & = & \frac{16}{8} \\
 x & = & 2
 \end{array}$$

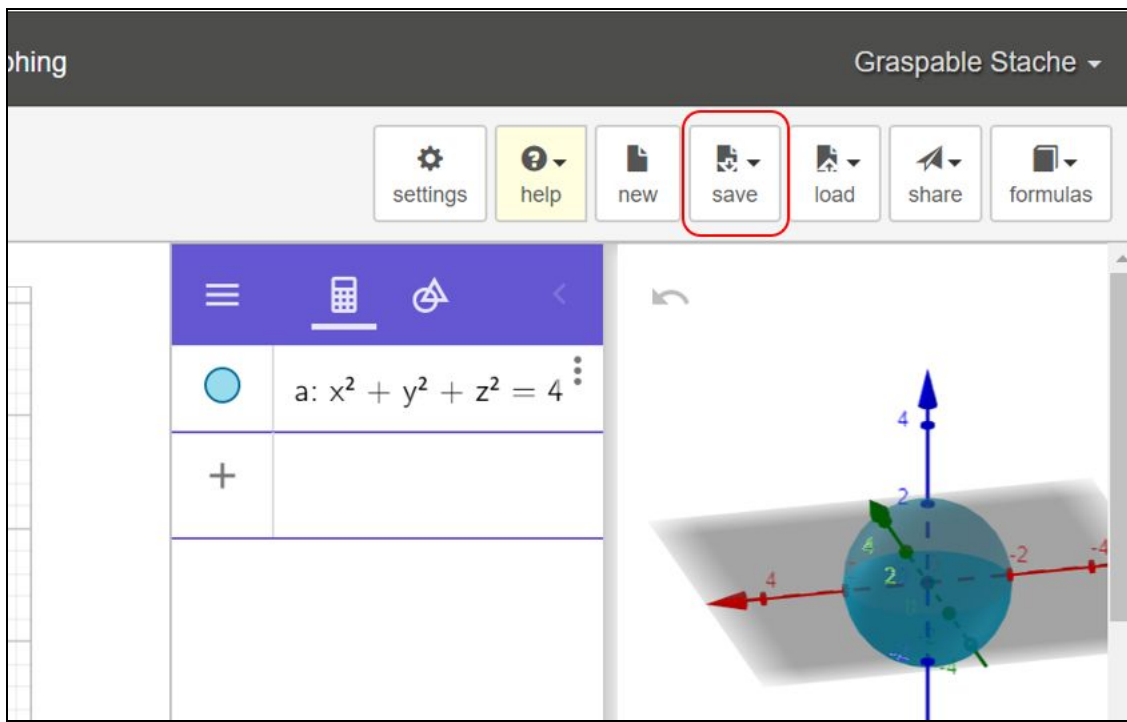
Toolbar: insert, transform, keypad, scrub, draw, erase, arrange, undo, redo, smaller, larger

$$\begin{array}{rcl}
 8x + 6 & = & 22 \\
 8x & = & 22 - 6 \\
 8x & = & 16 \\
 x & = & \frac{16}{8} \\
 x & = & 2
 \end{array}$$

Saving the Canvas

After creating your Canvas, it is important to save your activity to preserve its integrity and prevent your work from getting lost. Before saving your Canvas, check if you are logged into your GM account and look over your work to make sure everything is how you want it.

1. To save your Canvas, select the “**Save**” button on the top right of the page.



2. A dropdown menu will appear, asking you to fill in the "Title" and "Description" boxes before saving your Canvas. Filling this information will help you better locate your lesson later, as well as allow others to easily find your Canvas if you choose to make it public.



Graspable Stache ▾

settings help new save load share formulas

Save your math!

Click the "Save" button to save your work on the Graspable Math server.

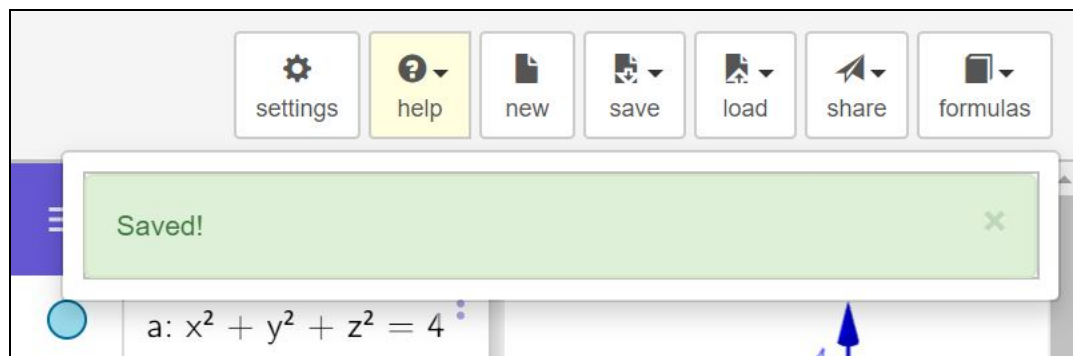
Title:

Description:

☐ Publish on GM materials web page.

Cancel Duplicate **Save**

3. Once you're ready to save your Canvas, select "**Save**" and your Canvas will be successfully saved when a green rectangle appears with the text "Saved!"

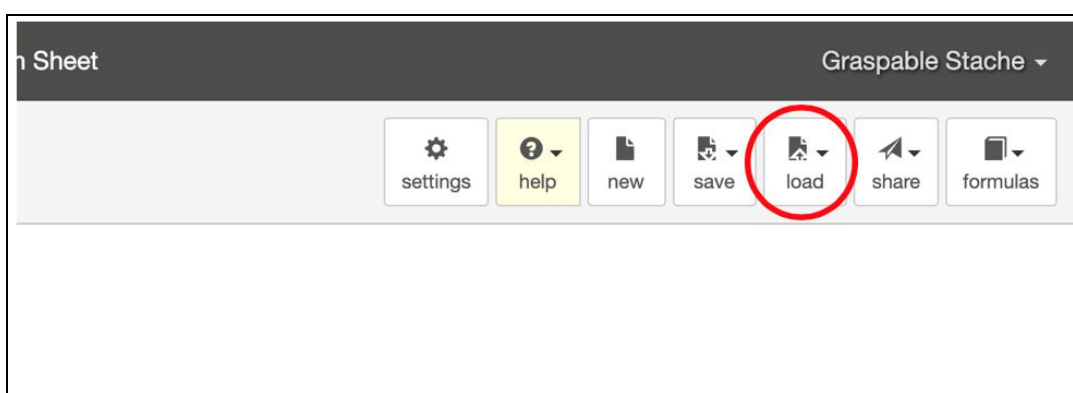




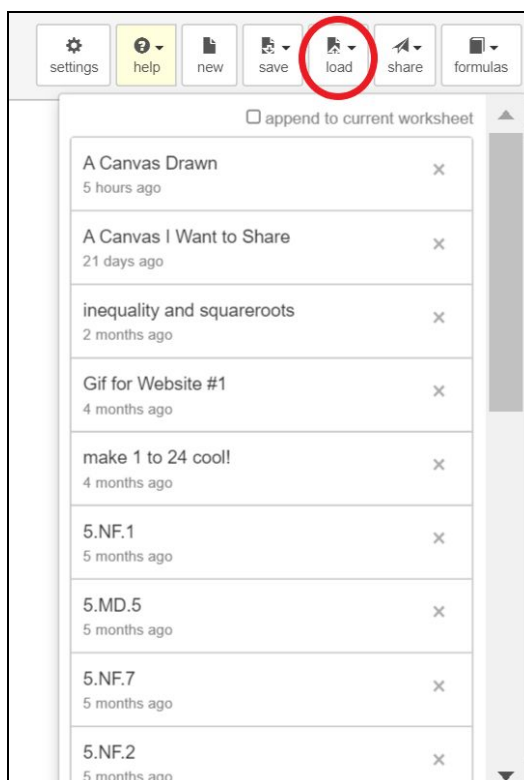
Loading the Canvas

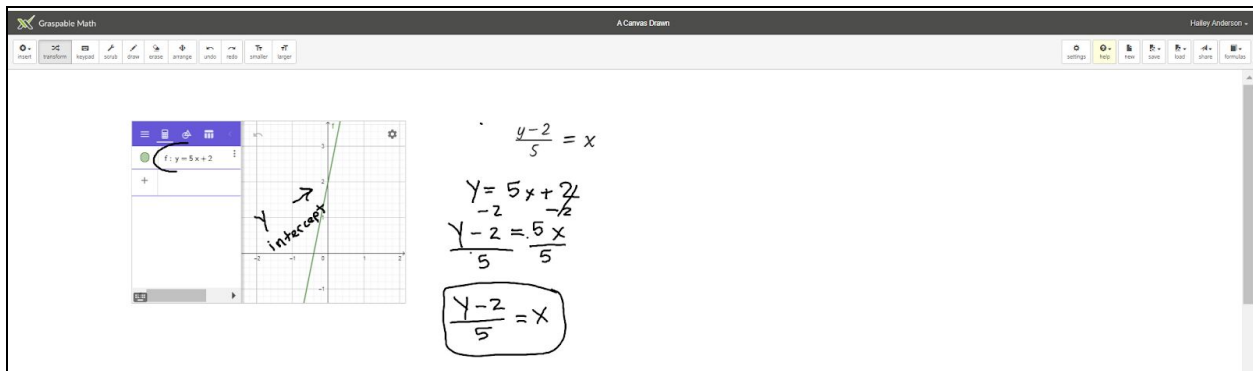
When you arrive at the GM Canvas page <https://graspablemath.com/canvas>, you will always automatically arrive at an untitled Canvas sheet.

1. To load a Canvas that you have worked on and saved, click the **“Load”** button on the upper right corner of the Canvas page.



2. A drop down menu will appear, showing all of the Canvas that you previously saved and can be loaded. Click on the saved Canvas that you want to load, and it will be displayed.

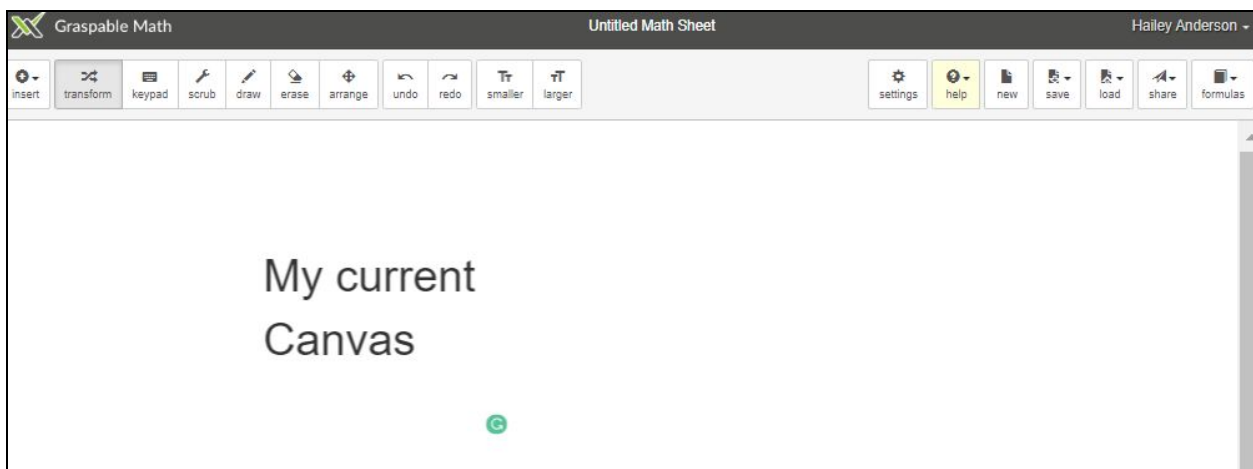




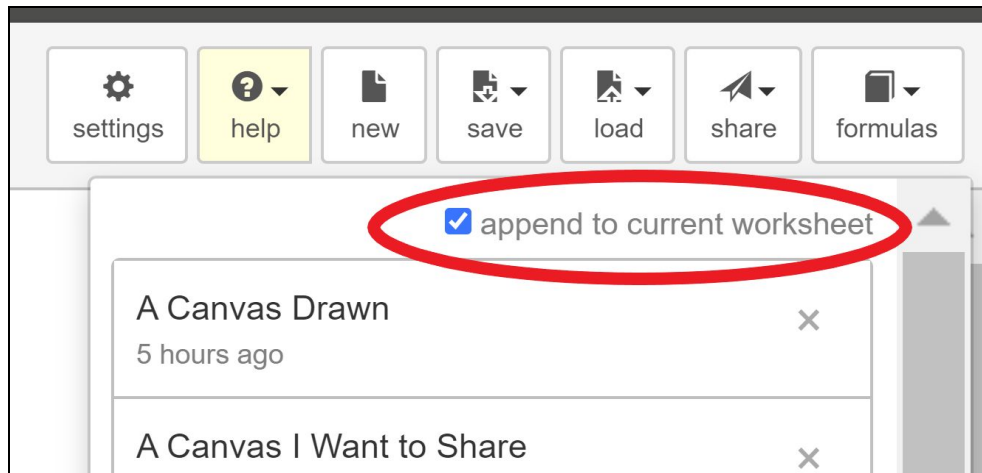
3. Once you've finished working on the loaded Canvas, don't forget to save your work to keep all the changes!

Adding Existing Content to the Current Canvas

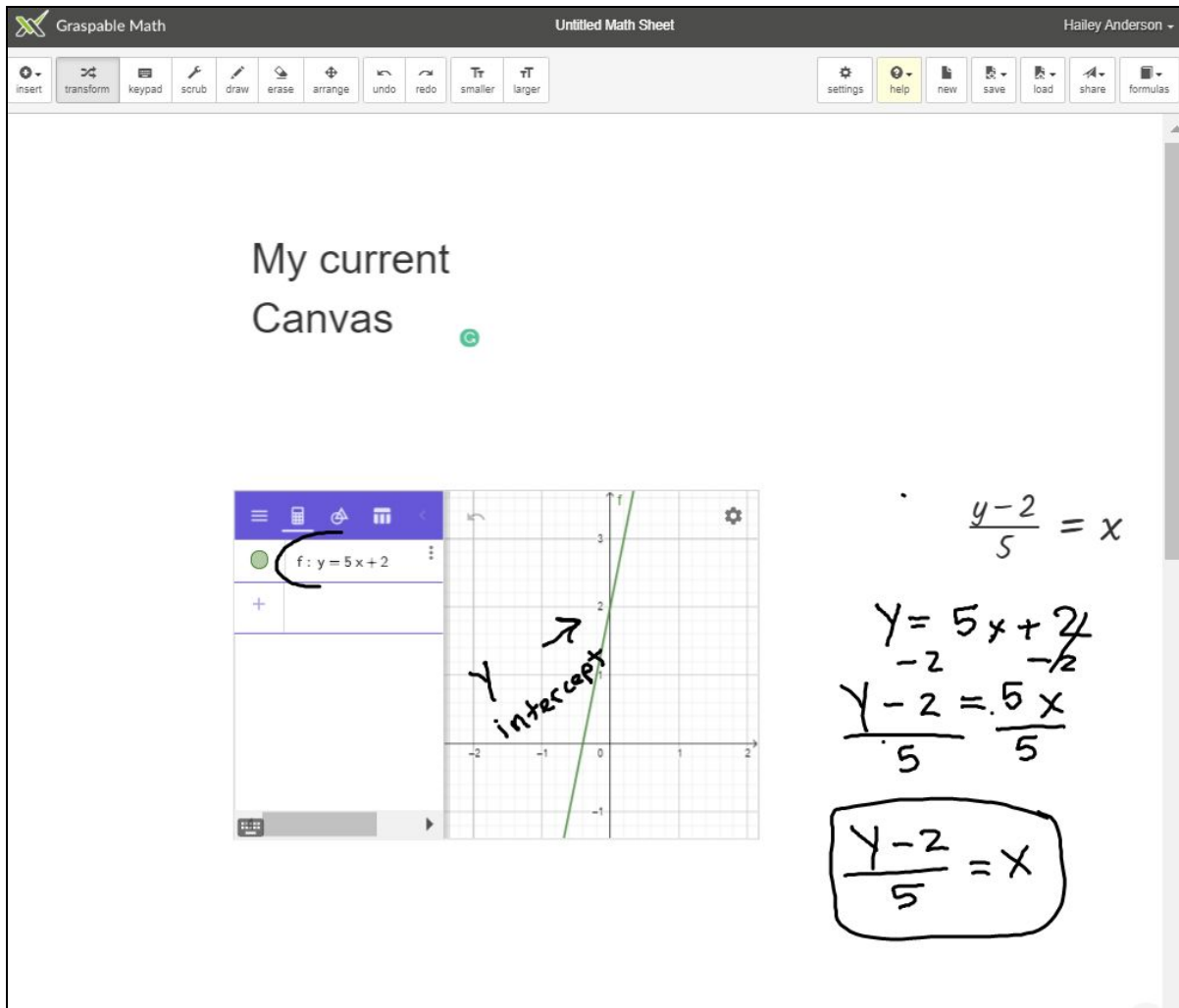
You can add content from a previously saved canvas to your current canvas. This is a good way to update your canvas, or to add new instructions or content for a specific target audience.



1. On the new Canvas you are working on, select the “**Load**” button, and click on the box saying “**Append to current worksheet.**”



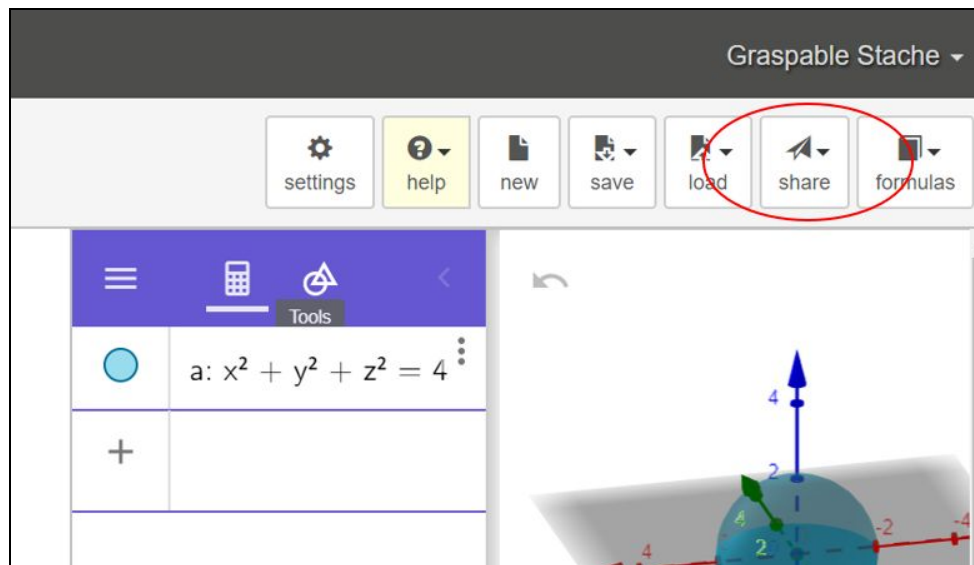
2. Then select the saved Canvas that you wish to add onto the new one you are working on. The selected Canvas will then be loaded and displayed onto your new Canvas.



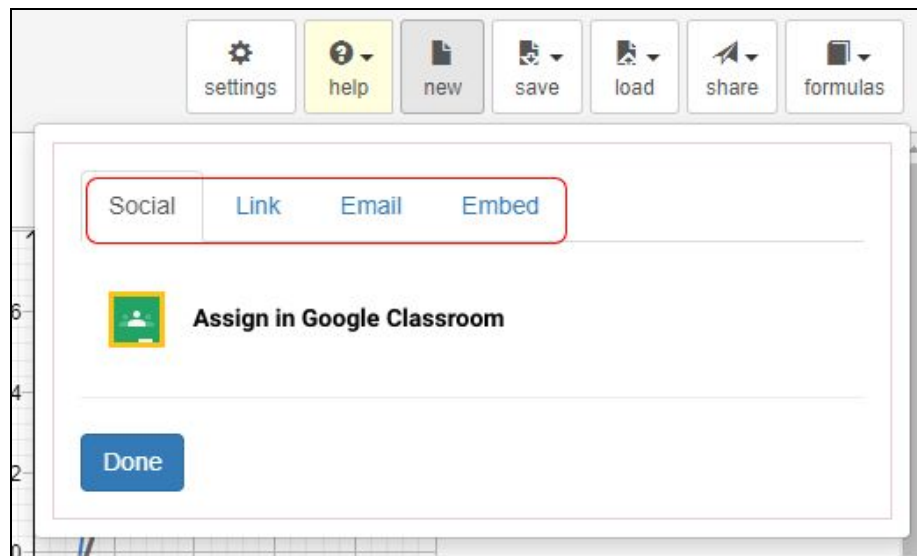
Sharing the Canvas

Once you have created an activity and saved your work, you may want to share it with your students or fellow teachers and creators.

To share your Canvas, locate the **"Share"** button at the top right of the page.

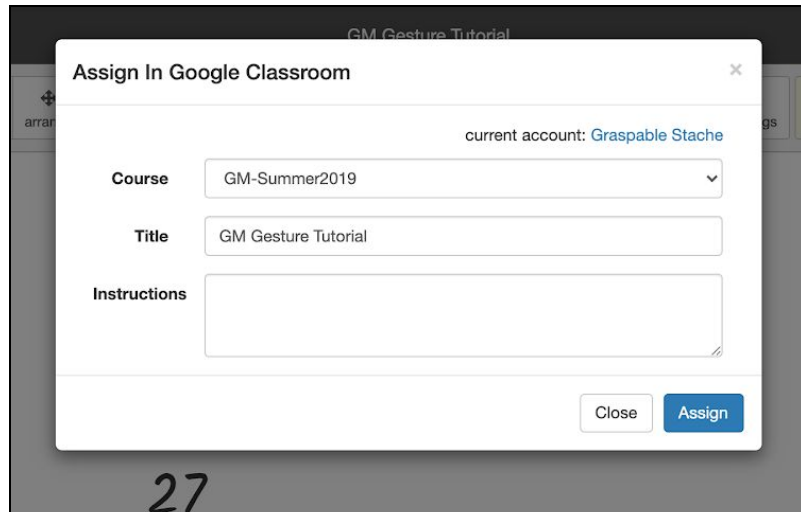


A dropdown menu will appear with 4 tabs: **Social**, **Link**, **Email**, and **Embed**. These are the four available methods of sharing your activity.



Social Sharing

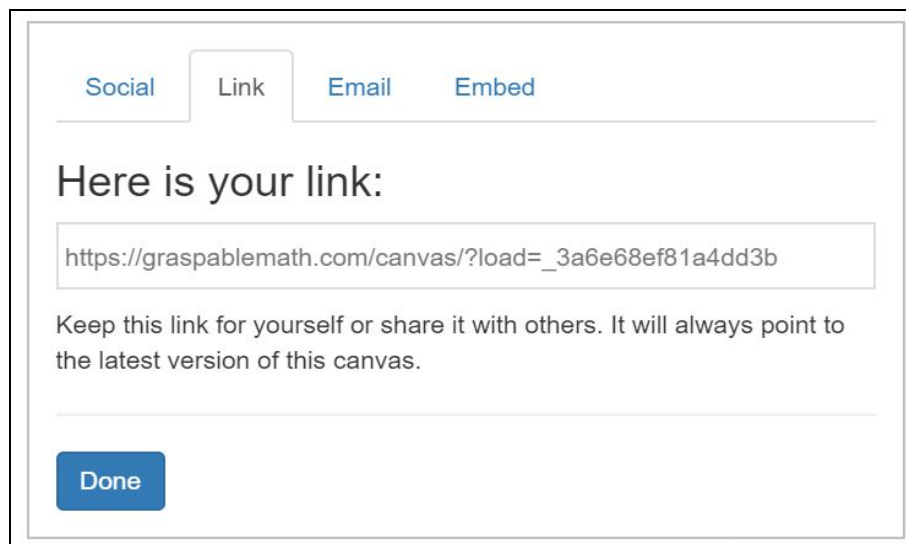
The **"Social"** tab currently connects to Google Classroom. Click **"Assign in Google Classroom"** to share your Canvas to the Google Classroom account connected to your Gmail.



Here are [more detailed instructions](#) on how sharing via Google Classrooms work.

Link Sharing

The “**Link**” tab provides a link to your Canvas. You can share this link to your students, peers or anyone by copying and pasting, and people with the URL will be able to view and copy your canvas.





Email Sharing

The **"Email"** tab provides a template that allows you to send out the link to your Canvas via email. If you choose **"Email"**, you will need to include recipients' email address, a subject, and any other content or instructions.

The screenshot shows the Graspable Math interface with the 'Email' tab selected. The 'Send Email!' button is circled in red.

settings help new save load share formulas

Social Link **Email** Embed

Send the share link in an email!

Subject:

GM Gesture Tutorial

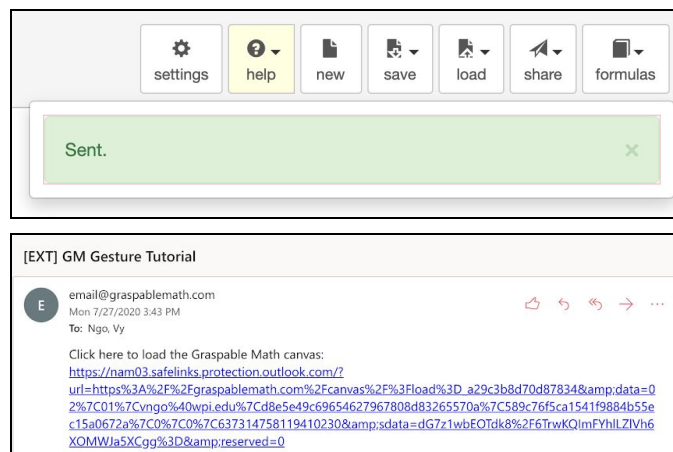
Content:

Click here to load the Graspable Math canvas:
https://graspablemath.com/canvas/?load=_a29c3b8d70d87834

Send to:

target@email.com

Send Email!



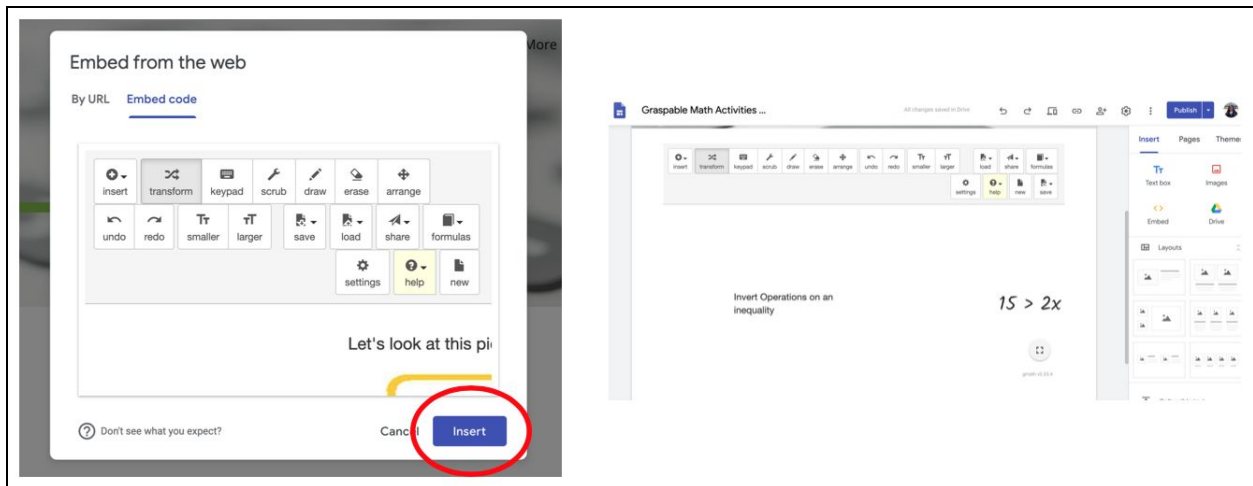
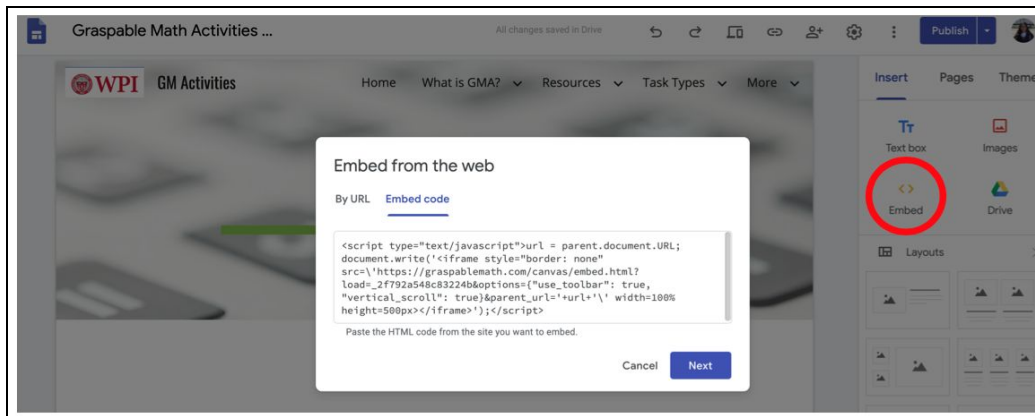


Embedding

The “**Embed**” tab provides code to insert your Canvas into a website. If you want to use the “**Embed**” option to embed your Canvas to a website, copy and paste the provided code into the HTML of the website.

The screenshot shows a web interface with four tabs: 'Social', 'Link', 'Email', and 'Embed'. The 'Embed' tab is selected. Below the tabs, there is a text instruction: 'To embed the saved GM canvas into your own webpage, put the following snippet into the body of your html file.' Below this instruction is a text box containing the following code snippet: `<script type="text/javascript">url = parent.document.URL; document.w`. At the bottom left of the interface is a blue button labeled 'Done'.

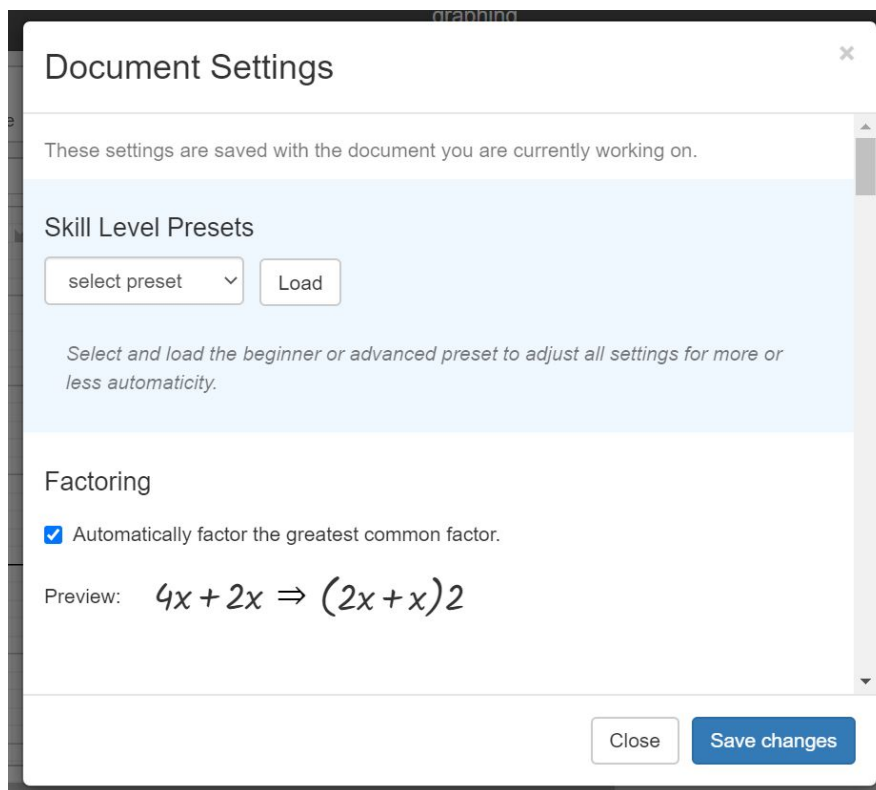
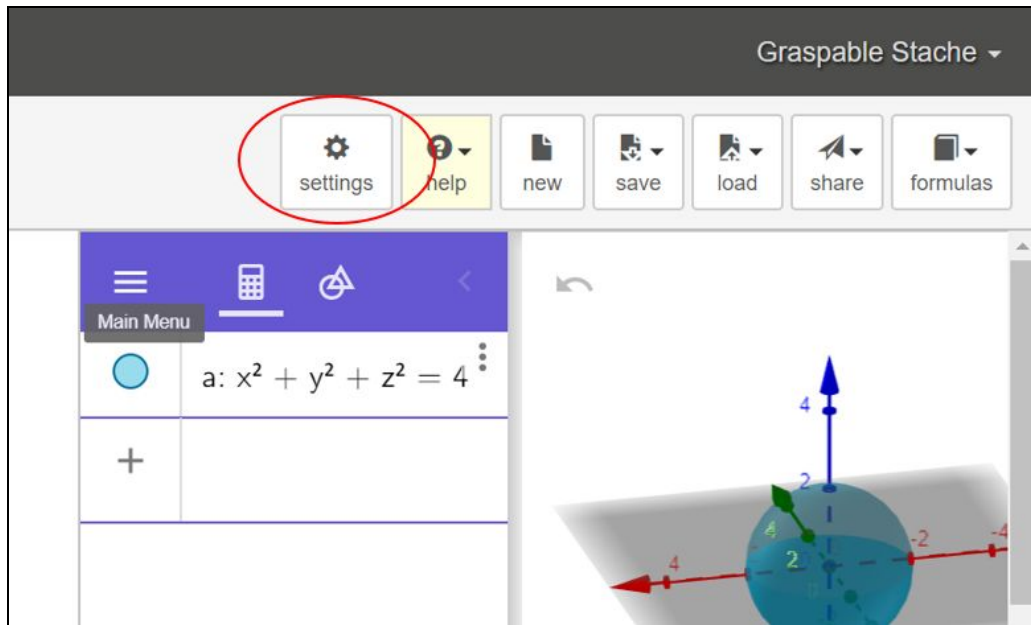
In the example below, we will show you a quick example of embedding a Canvas on Google Sites:



SETTINGS ON THE CANVAS

The behavior of algebra notation on the Canvas can be adjusted in the settings menu. The purpose of the document settings is to allow creators to adjust the amount of automaticity and scaffolding, as well as display preferences, to their intended target audience. For example, a 4th grade teacher may choose to display the multiplication sign as “x”.

Select the **“Settings”** button on the top right of the Canvas, and the **“document settings”** page will appear showing various settings available on Canvas.



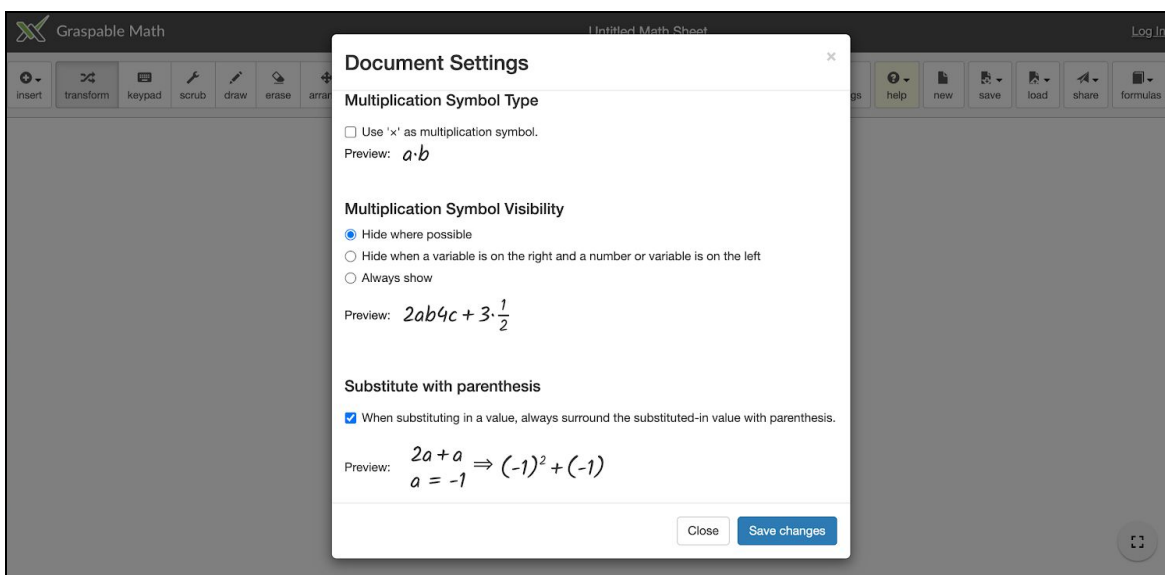


Document Settings

We will guide you through the setting menu and show you some of the settings you might find useful!

- **“Skills Level Presets”** allows the creator of the Canvas to adjust the difficulty of the settings. The **“Beginner”** setting will allow your students to use less GM functionality and stick to the basics, while the **“Advanced”** setting will include more high-level settings, such as:
 - Setting units for trigonometric functions
 - The type of multiplication symbol used; how and where a multiplication symbol can be seen
 - Whether GM shows the simplification on one click or multiple clicks to display each simplification step
 - How many decimal places should be allowed.

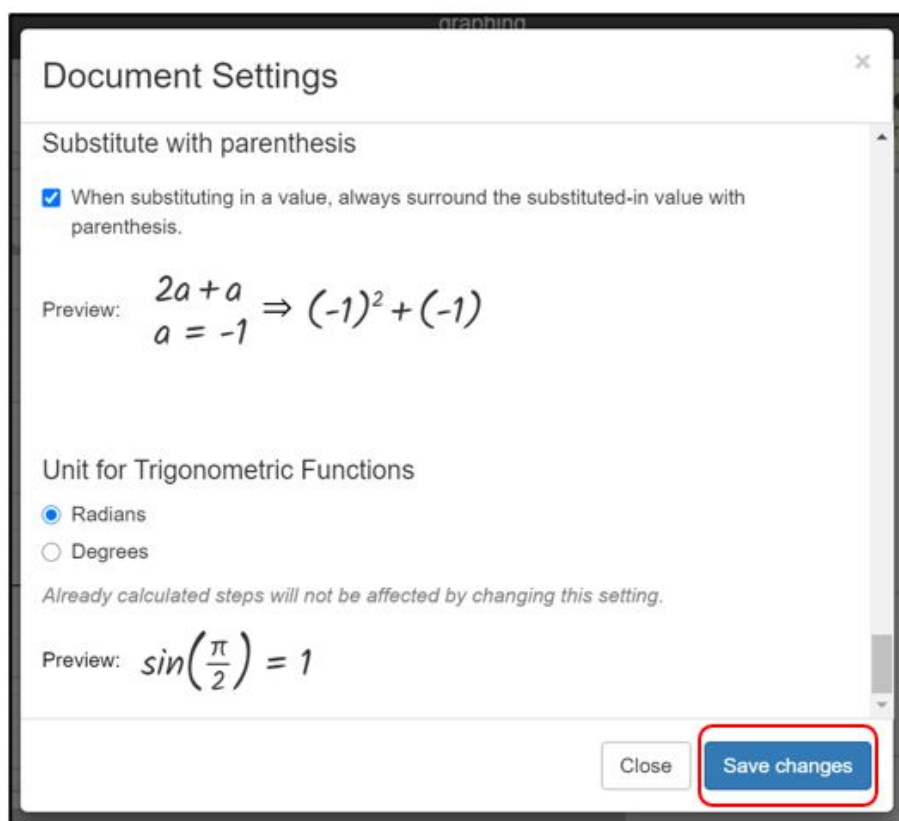
There are plenty of adjustments and settings you can do in GM Canvas. The ones above are just to name a few.





GM does include default “**beginner**” and “**advanced**” presets. However, you know your students best and we recommend you to set presets based on your students and their familiarity with Canvas or GM gestures.

Be sure to **save** your settings before exiting the “**Document Settings**” Window.



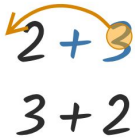
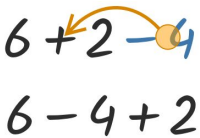
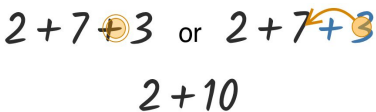
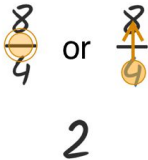
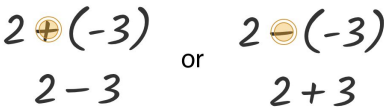
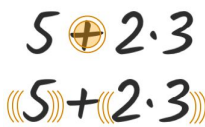


Frequently Used Gestures in Graspable Math


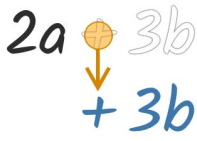
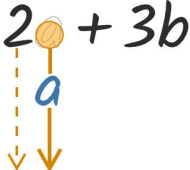
Tap, drag, and hold terms in Graspable Math to rewrite mathematical expressions into equivalent ones:

1. *Click or tap*: apply an operation (e.g. "+") or resolve parentheses ("(").
2. *Tap + drag*: drag terms where you want them to go to trigger the corresponding transformation. GM indicates valid places to drop a term with blue rectangles.
3. *Tap and hold*: apply a keyboard rewrite (e.g. hold "=" to enter an operation to apply to both sides of the equation)

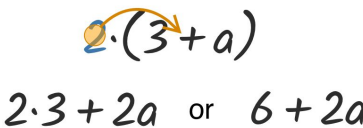
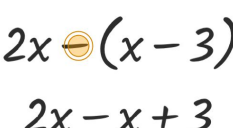
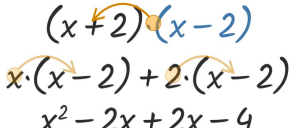
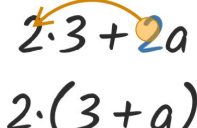
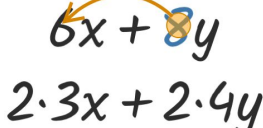
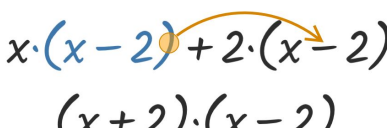
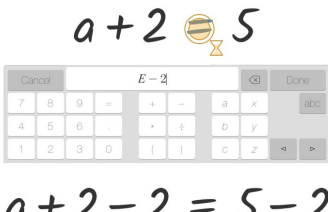
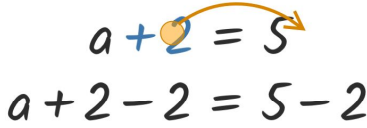
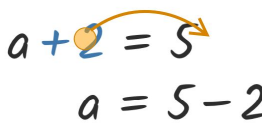
Operations, Commutative Property, Factoring

<p>Commute Terms Drag terms to commute.</p> 	<p>Commute Negative Terms In GM, a + or - is picked up with the term, so you can commute with negative terms.</p> 	<p>Perform Operations I Tap on operators or drag terms onto each other to add, subtract, multiply, etc</p> 
<p>Perform Operations II Tap the division bar or drag terms onto each other to divide.</p> 	<p>Combining Signs Tap the left sign to resolve "+-" and "-+".</p> 	<p>Order of Operations When tapping an operator that can't be applied, GM will shake the terms.</p> 



<p>Decompose and Factor Numbers Select "keypad" mode and tap on a number to replace it with an equivalent expression.</p> 	<p>Picking Up Multiple Terms I Pick up groups of terms by their operator or brackets around them, or fraction bar.</p> 	<p>Picking Up Multiple Terms II Pick up groups of terms by dragging down a term until more terms snap to it.</p> 
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Distributive Property, Rearranging Equations

<p>Distribute a Term Drag a term into parentheses to distribute. Automatically simplifies in advanced settings</p> 	<p>Distribute a Negative Sign Tap on the negative sign to distribute.</p> 	<p>Distribute Multiple Terms Drag one sum in another to distribute. Double-tap "(" instead to skip line 2 below.</p> 
<p>Factor a Term Drag common terms onto each other to apply the distributive property.</p> 	<p>Finding Greatest Common Factors When numbers don't match, GM finds their greatest common factor.</p> 	<p>Factoring Multiple Terms You can factor groups of terms, too.</p> 
<p>Equations: Do the Same to Both Sides I Tap and hold the "=" and enter an operation to apply to both sides in the keypad.</p> 	<p>Equations: Do the Same to Both Sides II Drag a term to the other side of the equation to apply the inverse.</p> <div style="display: flex; justify-content: space-around;"> <div data-bbox="623 1625 987 1793">  (auto-simplify setting off) </div> <div data-bbox="1094 1625 1354 1793">  (auto-simplify setting on) </div> </div>	



Equations: Invert Power I Drag the exponent across the "=" to invert it. $x^2 = 4$ $x = \pm\sqrt{4}$	Equations: Invert Power II Drag the base across the "=" to apply the logarithm to both sides. $2^x = 16$ $x = \log_2(16)$	Equations: Swap Sides Tap on the "=" to swap sides. $a + 2 = 5$ $5 = a + 2$
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Fractions and Powers

Turn Fraction into Decimal Tap on the fraction bar to compute. If the result is not an integer, double-tap. $\frac{10}{5}$ or $\frac{2}{5}$ 2 or 0.4	Adding Fractions I Tap or drag to add fractions with common denominators. $\frac{2}{5} + \frac{4}{5}$ or $\frac{2}{5} + \frac{4}{5}$ $\frac{6}{5}$	Adding Fractions II To rewrite fractions to have the same denominator, drag one denominator onto the other one. (Short-cut: double-tap "+") $\frac{1}{3} + \frac{1}{5}$ $\frac{2}{2 \cdot 3} + \frac{1}{2}$ $\frac{2}{2 \cdot 3} + \frac{3}{2 \cdot 3}$
Cancelling Fractions Drag matching terms on top of each other to cancel them out. $\frac{2a}{2b}$ or $\frac{a}{2b}$ $\frac{a}{b}$	Nested Fractions Drag a fraction out of the denominator to invert it. $\frac{a}{\frac{b}{c}}$ $a \cdot \frac{c}{b}$	Distribute Denominator Drag and addend out of the numerator or the denominator onto the numerator. $\frac{3+5}{3}$ or $\frac{3+5}{3}$ $\frac{3}{3} + \frac{5}{3}$



<p>Multiply Powers Tap the "*" or drag to multiply powers.</p> <p>$2^3 \cdot 2^5$ or $2^3 \cdot 2^5$</p> <p>2^{3+5}</p>	<p>Split Powers Drag an addend out of an exponent to split a power. (You may use keypad mode to replace an exponent with a sum first.)</p> <p>2^{3+5}</p> <p>$2^3 \cdot 2^5$</p>	<p>Distribute Exponents Drag an exponent into a product to distribute it.</p> <p>$(2a)^3$</p> <p>$2^3 \cdot a^3$</p>
<p>Factor Exponents Drag an exponent over matching exponents to pick them up, then drop them next to the product.</p> <p>$2^3 \cdot a^3$</p> <p>$(2a)^3$</p>	<p>Move Powers Across Fractions Drag a power across the fraction bar to invert the exponent.</p> <p>$\frac{2}{ab^2}$</p> <p>$\frac{2b^2}{a}$</p>	<p>Negative Exponent → Fraction Drag a power with a negative exponent down and drop it to create a fraction.</p> <p>x^{-1}</p> <p>$\frac{1}{x}$</p>