Creating Interactive and Mathematically Rich Activity with Desmos

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Chapter I: Introduction

Background
Task is the central component in mathematics teaching and learning. Well-developed task will facilitate student learning (Chapman, 2013) for many reasons. First, task can stimulate students to think about mathematical facts, concepts, principles, and procedures; to find connections between mathematical ideas; and to seek the applications of mathematics in their daily life (NCTM, 1991). Second, task can direct the students’ attention to the particular mathematical idea (Doyle, 1983). Therefore, the task bridges teaching and students’ learning. Third, task can be used by teacher to provide entry point for students in learning a specific mathematical content (SanGiovanni, 2017, pp. 3). Last but not least, task provides an environment in which students practice on particular mathematical skills. The practice leads students to be more fluent learner.

Even though task is an important aspect in mathematics teaching and learning, its roles as learning tool will be meaningless if teacher and student do not engage in implementing the task. Teachers have important roles in constructing successful tasks to facilitate the students’ learning. There are two important teachers’ roles when it comes to making successful tasks. First, selecting or developing tasks in order to make suitable learning environment for students’ learning. Second, optimizing the learning potential of the selected or developed tasks (Chapman, 2013). In carrying out these roles, the teacher must have the knowledge about mathematical task for teaching, especially knowledge about the nature of mathematical task.

In general, mathematical task can be classified according to its goal, method, complexity, answer, and extension. These aspects categorize mathematical task into several types namely procedural task, problem-solving task, investigative task, and real-life task (Yeo, 2017). Understanding the nature of each type of mathematical task will help teachers in selecting and developing appropriate tasks for their students. For example, if the teachers want to develop their students’ procedural fluency, then procedural task will be the best option to facilitate the students’ learning in mathematics (Foster, 2013).

Knowledge of how the task implemented in classroom is also important to be possessed by the teachers. The way in which the task implemented in classroom will influence students in making sense of, doing, and applying mathematics (Stein, Grover, & Henningsen, 1996). The implementation of task in mathematics classroom should pay attention on various factors, e.g. classroom norms, task
conditions, and students’ interest. An effective tool that can be used to deliver mathematical task is technology (Polly, 2016), one of them is graphing calculator.

Graphing calculator is a promising tool to implement mathematical task that can provide multiple representations for students. Graphing calculator can be incorporated in mathematics classroom as computational tool, transformational tool, data collection and analysis tool, visualizing tool, and checking tool (Doerr & Zangor, 2000). As a computational tool, the graphing calculator is used to evaluate, estimate, and round numerical expressions. As a transformational tool, the graphing calculator has potential in transforming computational task into interpretative task. It also can be used to store, compare, and re-collect the data set. Furthermore, graphing calculator has a role as a visualizing tool since it can be used to (1) find equations that fit data sets, (2) understand the characteristics of function by graphing the function in an appropriate views, (3) represent physical phenomena into graph visualization, and (4) to solve equations by representing them as graphs.

Many studies have been conducted to investigate the effectivity of the use of graphing calculator in mathematics classroom. NCTM (2011) reported a research brief entitled Using Calculators for Teaching and Learning Mathematics and found that the use of calculator “enhances the understanding of mathematics concepts and student orientation toward mathematics.” Clark-Wilson (2010) added that the use of calculator with networking capabilities also offer opportunities to promote collaborative learning environment in which students can learn from each other. Furthermore, this kind of content-specific mathematics technology can enhance students’ engagement. However, it should be noticed that the use of calculator in mathematics teaching and learning should be designed to emphasize the students’ conceptual and problem-solving skills, rather than as a drill and computational practice.

Desmos is one example of graphing calculator that is frequently used in school. Desmos is a web-based application that is developed “to help every student learn math and love learning math” (Desmos: about us., n.d.). Desmos offers two mainstays products to achieve its goals, i.e. graphing calculator and classroom activities. Its graphing calculator provide powerful tools to draw graphs for given mathematical expressions, to create a mathematical model that fit to a given data, and to do others common function of graphing calculator. Desmos also developed many digital activities that teachers can directly adapt for their classroom use, as well as activity builder for teachers who want to build their own activity (see Kristanto, Melissa, & Panuluh, 2019).

Purpose

Given the demand on teachers to be able to select or develop mathematical task which optimize students learning and the promising potential of Desmos as
graphing calculator and digital activity builder, consequently this module proposes two aims. First, to help teachers getting insight on how to design effective mathematical tasks. Second, to provide step-by-step tutorial on utilizing Desmos to create mathematical tasks for students.

**Learning Outcomes**

By the end of learning process provided by the present module, it is expected that the teachers will be able to:

(a) Create problem-solving, investigative, and real-life tasks to promote students’ understanding about mathematical ideas.

(b) Use Desmos as graphing calculator and digital activity builder to make effective mathematical tasks that facilitate students’ learning.

**Scopes**

This module discusses problem-solving, investigative, and real-life activities and then translate those activities into Desmos environment. The mathematical topics covered in this module are the topics in middle school level.

**Prerequisites**

The prerequisites of this module are basic skills on Desmos’ graphing calculator and classroom activities as well as the competencies on middle school mathematics. Basic knowledge on Desmos can be learned on the previous Desmos series module (see Padmi, 2019).
Chapter II: Problem Solving

Description
Problem-solving skill is important skill to be possessed by our students in 21st century (Ananiadou & Claro, 2009; Trilling & Fadel, 2009, p. 50). The students’ problem-solving skill can be boosted by providing regular and consistent opportunities for them to solve problems. However, creating and presenting appropriate yet rich problems for students are no easy feat. Therefore, this chapter offer a problem presentation method by using Desmos graphing calculator. This method emphasizes the use of visualization to elucidate implicit aspects of a mathematics problem.

Learning Objectives
By the end of this chapter, you are expected to be able to:
• create a mathematical task to foster the students’ problem-solving skills.
• represent a mathematical problem-solving task to Desmos environment to give clear visualization to students.
• use dragging feature in developing Desmos-based task to provide dynamic object for students to explore.

Creating Problem for Desmos
The main feature of Desmos as a graphing calculator is to draw geometric objects, such as point, lines, and curves. On top of this ability, Desmos also has capabilities in constructing dynamics objects. Dragging feature in Desmos can accentuate certain aspects of a geometric object while other aspects remain constant. We will use this feature to create visualization for mathematics problems, which is as follows.

ACTIVITY’S PRIMARY OBJECTIVES
• Transforming a word problem into mathematical models.
• Finding the shortest path connecting two given points.
• Using Pythagorean Theorem to solve a problem.

Connecting two villages. There are two villages and a highway, as shown in the Figure 1. The local government want to connect those two villages with a road that must cross the highway. What is the minimum length of the road?
Figure 1. A road connects two villages

In solving the given problem, it will be helpful for students if they can visualize the varied length of the crossroad. Specifically, the students can imagine what happened to the road when the crossroad shift to the left or to the right. Let’s see how can accomplish it with Desmos.

Translating the Problem into Desmos Environment

The “connecting two villages” problem can be presented in Desmos graphing calculator by plotting corresponding two dots and three lines. General steps in presenting the problem are as follows.

1. Draw a horizontal line $y = 0$ as a representation of the highway, then plot points with coordinate (0, 4) and (12, 5). These two points are a representation of the villages. Make sure to scale the Desmos such a way so that all points appear in the screen. If necessary, don’t show grid, $x$, $y$-axis on the screen.

2. Construct two line-segments whose one end is at one of the two plotted points and the other end meets at a point at the highway. Make sure that the point at the $x$-axis is located between the points, for example at (5, 0).
3. In this step we will make the intersection between the highway and the road dynamic. In other words, we make the crossroad to be shiftable to the left or to the right. This means that the point (0, 5) will keeps changing as it moves back and forth, such that at certain points it will be (0, a). What are the equation of the lines that connect each of the two points to (0, a)? If we input these equations into the Desmos, then we will get the slider \( a \).

The value of \( a \) in the slider will vary, depends on the range we set. If the value changes, so does the visualization of the graph of the roads.

4. The dynamic visualization in step 3 can be used by teachers to demonstrate the variation of possible crossroads to the students. It is expected that the students will see the variation of the road lengths when the crossroad position varies. However, this visualization does not provide clear picture to students where the position of the crossroad that give minimum length of the road. To provide clearer picture, we can draw reflection of point (0, 4) respect to the highway and connect this point to the crossroad.
By changing the values of $a$, students will see more clearly when the road have the minimum length is. That is, the minimum length will happen when the reflection of the first village, crossroad, and the second village are colinear. It is expected that, then, students will use Pythagorean theorem to solve the problem.

5. The final version of the problem can be accessed by clicking the following link: [https://www.desmos.com/calculator/ahki3tmey5](https://www.desmos.com/calculator/ahki3tmey5).

In summary, the role of Desmos’ graphing calculator in this activity is to provide visual scaffolding to students. By showing the difference positions of crossroad, it is expected that students will realize how the road length varies. From this understanding, students will hypothesize that there is a minimum value of the possible of the road length. The visualization we provide in step 4 is intended to give clearer picture for students where the crossroad is so that the length of the road is minimum.

**What’s Next? Number Problem**

System of linear equations in two variables is one of the topics to be covered in middle school. Usually, the system is solved by using substitution, elimination, or graphical method. In this section, an alternative method is proposed to solve the system. In applying this method, your students are invited to use tables to list some possible solutions as ordered pairs and plot the ordered pairs in the table with Desmos graphing calculator.

A number problem is also proposed to illustrate the application of the method. In this

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**ACTIVITY’S PRIMARY OBJECTIVES**

- Finding a point that satisfy the given equation.
- Reasoning about the pattern formed by the graph of a set of points on the coordinate plane.
- Solving systems of equations in two variables by using table.
kind of problem, the students are asked to find two numbers that satisfy two given conditions. For example, the students are asked to find two numbers that have a difference of 2 and a sum of 8. To solve this problem, we will facilitate them by providing a Desmos interactive activity.


2. First, add note to the lists panel that tells the learning goal to your students. Your note may be like this:

   *Here is your goal. Find two numbers that have a difference of 2 and a sum of 8.*

3. In achieving their goal, we will engage your students to dig into the problem with table. We will give a list of several numbers $x_1$. These numbers should be assumed as smaller numbers, and ask the students to find their pair, $y_1$, so that the difference between each pair is 2.

4. Next, we add a note to give a question to the students. This question is intended to enable students observe and find a pattern, and then interpret the pattern they found. The example of the question is as follows.

   *The plot of ($x_1$, $y_1$) can be seen in the right side. Why are they lined up so neatly?*

   The display of our lists panel by this time is shown in the figure below.

   ![Desmos list panel](image)

5. The next step is like the step 3 and 4. In this step, we ask students to complete the given table so that the number pairs in each row has a sum of 8.
6. Next, we ask the students to find a point that is included in both of first and second table and interpret such point with regard to the initial problem.

By following the developed activity, it is expected that your students be able to solve the number problem. This problem can be used to serve as entry point for students to understand graphical method in solving system of linear equations in two variables. For example, you can expand this activity so that the students also learn how to graph a line that passing through all points. By this, the students will understand the idea of lines’ point of intersection as the solution of the system of linear equations.

**Exercises**

1. Make the crossroad to be a draggable point so that students can drag this point directly to shift the crossroad to the left or to the right.

2. Create another problem for middle school students that use dragging feature of Desmos. For example, you can provide a problem that ask students to model the area below the line that passing through (4, 2) as a function with respect to the line’s gradient $m$. In this problem, you should restrict the values of $m$ to be negative numbers (see the Figure 2).
**Figure 2.** Example of area problem
Chapter III: Mathematical Investigation

Description
Mathematical investigation activities create meaningful learning for students. However, these kinds of mathematical activities are often difficult to be implemented. Desmos offer various features that have potential in attracting student to learn mathematics. Desmos can be utilized to build interactive activities that enhance students’ engagement. The slider that will be used (again) in Activity I and II in this chapter can be utilized as a means to visually scaffold students in understanding complex concepts. The interactive activities built in Desmos can facilitate students to communicate their reasoning to their fellow student. We will also use Desmos’ Marbleslides in this chapter, which will make learning environment to be more fun since this feature will gamifying students’ learning. All of these Desmos’ features will be used to created mathematically rich (but fun) activities in this chapter.

Learning Objectives
By the end of this chapter, you are expected to be able to:

- select a classroom activity from Desmos website to enhance students’ understanding on mathematical concepts.
- build a classroom activity by using Desmos activity builder that suitable for students’ context.

Selecting Classroom Activity
Desmos.com has built many classroom activities which directly can be selected to be used in mathematics classroom. To do that, please go to the Desmos website, https://www.desmos.com and then choose Classroom Activities, or directly go to the https://teacher.desmos.com/.
On the Desmos’ classroom activities page (see Figure 3), you will find many activities that can be chosen. In this page, you can use menu bar on the left side to find an appropriate classroom activity. You can pick an activity from Home, Most Popular, or Bundles.

**Get Familiar with Classroom Activity**

As for an example, from Desmos’ classroom activities page, choose the Functions bundle, find for “Marbleslides: Lines” and click it to choose the activity. After you choose the activity, you will be directed to the Marbleslides: Lines page (see Figure 4) where you can create a Class Code and view the Student Preview. A Class Code is the code that the students must input on the Desmos’ student page to access the activity.
To get familiar with the chosen activity, please click on the Student Preview button. In the student preview, you will find 24 slides in which the activity is presented and sequenced. First slide shows the learning objective of the activity, i.e. “Get all the stars. Get to know lines.” It will be evident that is a game-based task for students to manipulate the equation of a line. You should preview all slides before using the activity for your classroom.

**Create an Investigative Task**

After you got the picture about Desmos’ classroom activity, now it’s time to build our activity by our self. First, we should concept the activity. It means that we should decide the learning goals and the learning sequence. As an illustration, we will create a Desmos’ activity to facilitate students’ understanding on y-intercept of linear function. Therefore, we should identify key skills that students’ need to acquire. The skills are:

- determining the value of $y$ when $x = 0$
- finding the $y$-intercept of a given line
- exploring the $y$-intercept of $y = mx + c$ when the values of $c$ are varies

In supporting students achieve those key skills, we should provide a set of appropriate mathematical tasks. The mathematical tasks can be sequenced as shown in Table 1.

<table>
<thead>
<tr>
<th>Key skill</th>
<th>Key activities</th>
</tr>
</thead>
</table>
| 1. Determining the value of $y$ when $x = 0$ | • Evaluate the value of $y$ by substituting $x = 0$ to the linear function  
• Interpreting an ordered pair $(0, y)$ as the intersection point between the linear function and $y$-axis.  
• Show the $y$-intercept on a graph |
| 2. Finding the $y$-intercept of a given line | • Understanding $y$-intercept of a line  
• Determining the coordinate of the intersection between $y$-axis and a line |
| 3. Exploring the $y$-intercept of $y = mx + c$ when the values of $c$ varies | • Observing the $y$-intercept of $y = mx + c$ for the difference $c$  
• Determining the variable in $y = mx + c$ that represent the $y$-intercept |
Finding the equation of a line by observing its y-intercept.

In supporting students’ understanding on y-intercept of a line, we can provide learning environment in which they can manipulate the line and observe its implication on the graph. This observation provides visual scaffolding to students so that they can make conclusion with regard to y-intercept of a line. This learning environment can be provided through Desmos interactive activities.

**Activity I: Understanding the y-intercept of A Linear Function**

We will utilize the Desmos activity builder in transforming our ideas as shown in Table 1 into interactive activities. Follow these procedures to develop Desmos activities as a means to provide interactive learning environment for students.


2. Add a title of your activity. For example, we can use “Investigation of y-intercept” as our activity title. Click “Start Building” to begin the activity development process in Desmos activity builder.

3. Workspace of Desmos activity builder has three different areas. In the Screen pane, you can work directly on individual screens, such as adding graph, table, and sketch. The Screens tab shows a thumbnail version of each full-size screen shown in the Screen pane. In this tab, you can add a new screen by clicking New Screen button. To make a particular screen appear on the Screen pane, click a thumbnail of the screen on the Screens tab. On the top of Screen pane, you can add a title or instructions for the students.
4. In the first screen, we will tell the students about the learning goals by adding a note on the screen. Therefore, the first screen can be organized as shown on figure below.

5. Click “New Screen” in the Screens tab to create second screen. In the second screen, we will ask the students to evaluate a particular linear function when $x = 0$, then invite them to represent the result as a point in $y$-axis. To do this, we write the instructions on the title of second screen, “Given the equation $y = 2x + 5$. Drag the red point on the graph to represent the output when $x = 0$.” On the Screen pane, we add Graph that include two items, namely a point coordinate $(0, y_0)$ and the slider $y_0$. 
6. We add similar activity on the third screen, but by utilizing different features of Desmos activity builder. For example, we can add Card Sort. In Card Sort activity, students are asked to pair two cards that have relationship. When using this activity, do not forget to add answer key.

The concept of Card Sort is identical to matching question type. In Card Sort, a card must be correctly matched against another card. This feature can be used to improve students’ skills in finding the intersection point between a line and $y$-axis. By using this feature, we can ask students to match equation card with its $y$-intercept. Table 2 shows the example of equation card and its matched $y$-intercept.

Table 2. 
*Equation card and y-intercept card used in third screen*

<table>
<thead>
<tr>
<th>Equation card</th>
<th>y-intercept card</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y = 2 - x$</td>
<td>$(0, 2)$</td>
</tr>
<tr>
<td>$y = (5x - 4)/2$</td>
<td>$(0, -2)$</td>
</tr>
<tr>
<td>$y = 4x - 1$</td>
<td>$(0, -1)$</td>
</tr>
</tbody>
</table>
7. In fourth screen, we will ask students to find the y-intercept of a given line. Therefore, it is necessary to define the y-intercept in this screen. In achieving these goals, we can set the fourth screen as follows.

| $y = 2x - 1$ | (0, 1) |

In the fourth screen above, we utilize Graph, Note, and Input features in Desmos activity builder. In Graph, we add expression $y = x + 3$. Then, we add a note as follows.

“The y-intercept is where a graph crosses y-axis. Look at the graph on the left side. Click the point at which the graph crosses the y-axis. Then write the coordinates in the box below.”

Finally, we add Input so that the students can enter their answer to the question given in the aforementioned note.

8. In order to make students more fluent on finding the y-intercept of an equation, we can use Choice. For example, we can give this question in the fifth screen title.

“What is the y-intercept of $y = 3x + 2$?”

Then, choose Choice from the Screen pane and add −2, 0, 2, and 4 as possible answers. We can select Explain in Multiple Choice subcategories. With this feature, students should explain their thinking about their answer. The final display of the fifth screen shown below.
9. We will set the sixth screen in facilitating students to explore what happen in y-intercept of $y = mx + c$ when $m$ and $c$ vary. Thus, we will use Graph to graph $y = mx + c$, then add $m$ and $c$ sliders.

In this screen, students can adjust both of $m$ and $c$ sliders. From this activity, it is expected that students will be able to make a conjecture regarding which variable ($m$ or $c$) that represents the y-intercept.

10. The students’ written conclusion about y-intercept will be accommodated in seventh screen. In this screen, we add question as a Note for students to make a conclusion. In making their conclusion, the students can choose the right answer from multiple choice. Therefore, aside of Note, we need to add Explain from Choice subcategories.
11. In accommodating students to use their conclusion about $y$-intercept, we can provide an exercise for them in eighth screen. The exercise can be created in various ways. One possible was is by using Graph, Note, and Input. In the Graph, we can provide a line that has equation $y = -2x + 5$. In the Note, we add question “The graph on the left side has equation $y = -2x + c$. What is the value of $c$? Explain your answer.” The final display of this screen is shown below.

12. The eighth screen is the last screen of our activities. Click Next on the top-right of the page and, if necessary, add image and description of the activities. When you finish, click Done.

In summary, we have created eight-screen activity to facilitate students in understanding the concept of $y$-intercept. The activities we created in Desmos activity builder are used as a means to achieve key skills they needed. The key skills are (1) determining the value of $y$ when $x = 0$, (2) finding the $y$-intercept of a given line, and (3) exploring the $y$-intercept of $y = mx + c$ when the values of $c$ varies.

We have used various features in Desmos activity builder when creating all activities in each screen, namely Graph, Note, Input, Choice, and Card Sort. The features that not be used yet are Table, Sketch, Media, Marbleslides, and Ordered
List. You can explore the remaining features in by creating additional screens in previous activities.

**Make the Activity Available for Student**

In previous section we have created a set of mathematical activity. Unfortunately, the activity is not directly accessible for your students. We need to make the activity available by creating class code. This can be done by clicking “Create Class Code” on the activity page, see Figure 5.

![Figure 5. Click Create Class Code to make the activity available](image)

After you create class code, you can share the code to your students. This code is used for the students to enter your activity from student.desmos.com. Aside of that, you can manage your activity in the activity’s dashboard.

**Activity II: Investigating the Properties of Quadratic Function**

Understanding the properties of quadratic function is critical for students in studying the topic of quadratic function. Therefore, we will build a set of activities that facilitate students to investigate the properties of quadratic function in standard form, that is \( f(x) = a(x - h)^2 + k \). The learning goals are to make the students be able to find the effect of \( a \), \( h \), and \( k \) to its graph.

1. Go to Desmos activity builder and create a set of activities entitled “Investigating the Properties of Quadratic Function.”

**ACTIVITY’S PRIMARY OBJECTIVES**

- Recognizing the quadratic function in standard form.
- Describing the characteristic of quadratic function.
- Finding the best parabolic curve that fit for the given points.
2. Write the learning objectives in first screen. The learning objective is as follows.

"Students explore the effect of changing each of the parameters $a$, $h$, and $k$ in standard form of quadratic function, that is $f(x) = a(x - h)^2 + k$.”

3. In second screen, we ask students what happens when the parameter $a$ in the quadratic function $f(x) = a(x - h)^2$ vary. To do this, we can add Graph with the following items in the screen.

![Graph Screen](image)

4. We ask students to conclude about the effect of parameter $a$ on the graph of quadratic function in third screen. Therefore, we can use Graph, Note, and Input.
5. We repeat step 3 and step 4 for screen 4 – 7, but in these screens, students investigate the effect of remaining parameters, i.e. $h$ and $k$, to the graph of quadratic function.

6. After the students understand the impact given by the value of parameters $a$, $h$, and $k$ to the graph of quadratic function, then they ready to apply those properties to solve a vertex problem. Therefore, in the eighth screen we provide this kind of problem. In this problem, we can give a particular point, for example $(-2, -3)$, then ask the students to adjust the parameters $a$, $h$, and $k$ of $f(x) = a(x - h)^2 + k$ so that the vertex of the function’s graph coincide with the given point. The preview of the eighth screen is shown below.

7. In ninth screen, we invite the students to conclude with regard to the relationship between the vertex coordinate and the values of $h$ and $k$. 
Let’s make the students play with the graph of quadratic function! To do so, we can use Marbleslides in the tenth screen. First, we should tell the students that their goal is to get all the stars on the screen by sliding a ball on a parabolic path. We put the stars at \((-2, 0.55), (0, -0.25), (2, -1.45), \) and \((4, -3.05)\), whereas the ball is at \((-4, 2)\). The appropriate path of the ball to get all the stars is a parabola with the equation $f(x) = \frac{-1}{20}(x + 5)^2 + 1$. However, in our Graph, we change the sign of $-1/20$ to be positive so that students should fix this to get all the stars. The preview of Marbleslides activity in tenth screen is shown below.

You can create another Marbleslides activity in eleventh screen. For example, in this screen you may invite your students to adjust $a$, $h$, and $k$ of the equation $f(x) = a(x - h)^2 + k$, rather than asking them to fix the sign of $a$, $h$, or $k$ (as in tenth screen).
10. That’s it! We have built eleven-screen activity to provide interactive learning environment for your students to investigate the properties of quadratic function. Remember to create class code for your students so that they can access your activity!

In conclusion, we have developed a set of interactive activities to make your students understand the properties of quadratic function in standard form. These activities invite the students to investigate the effect of parameters $a$, $h$, and $k$ to the graph of $f(x) = a(x - h)^2 + k$ by adjusting the sliders of the parameters. The activities also provide gamified exercises for students to apply their understanding.

Exercises

1. Develop a set of interactive activities by utilizing Desmos activity builder for your students so that they understand when a quadratic function in standard form crosses the $x$-axis. The learning objectives of the activities are as follows.

(a) Student understand what conditions to be satisfied by a quadratic function $f(x) = a(x - h)^2 + k$ so that its graph crosses $x$-axis at one point.

(b) Student understand what conditions to be satisfied by a quadratic function $f(x) = a(x - h)^2 + k$ so that its graph crosses $x$-axis at two different point.

(c) Student understand what conditions to be satisfied by a quadratic function $f(x) = a(x - h)^2 + k$ so that its graph does not crosses $x$-axis.

2. Using Desmos activity builder, create activities to promote students’ understanding on finding the equation of a line when its $x$-intercept and $y$-intercept are given. You also should provide gamified exercises in one or more screens by using Marbleslides.
Chapter IV: Real-Life Activity

Description
Developing real-life activities by using Desmos are the focus in this chapter. The first activity is about computational sketching. This activity transforms the students’ interest into meaningful learning regarding the concept of a line and its graph. The second activity has goal in making students to think critically through the modelling tasks. This activity also makes the students to become researcher in making data-based judgement.

Learning Objectives
By the end of this chapter, you are expected to be able to:
• finding real-life situation that effectively can be translated into Desmos environment.
• develop real-life-based activity by using Desmos to enhance students’ learning in specific mathematics topic.

Activity I: Sketching a Specific Picture Computationally
For some students, drawing is a fun activity. Thus, we will take advantage of this kind of students’ enjoyment to make them learning mathematics, particularly in applying the concept of the linear function graph. In detail, students will be given a specific picture on their screen, then they will be asked to write linear functions which models some aspects of the picture. For example, we can use the picture as shown in Figure 6.

ACTIVITY’S PRIMARY OBJECTIVES

• Determining the equation of a line.
• Finding the domain of a given line-segment on the coordinate plane.
Using picture on Figure 6, we can ask students to sketch a number of lines that coincide to some of the physical features of the building as shown in the pictures using Desmos graphing calculator. Follow these steps to build this activity.

1. Open the Desmos graphing calculator: [https://www.desmos.com/calculator](https://www.desmos.com/calculator). Then, login to your account and add the title of your graph. The title may be “Desmos Art: Skyscraper.”

2. Add picture to the Desmos graphing calculator by clicking “Add Item” on the top-left of your workspace, and then select “Image”. Choose the picture from your computer and adjust its center, angle, width, and height.

3. We add instruction to your students. In doing so, click “Add Item” again and choose “Note”. Type this instruction to the note field: Write linear function which models some aspect of this picture. Use a domain restriction, if you like.
By doing this activity, students will use their understanding on equation of a line. They may try to write a linear equation and refine the equation so that the graph of the equation fit with the one aspect of the given picture. As an illustration, some students write \( y = x \) as a start. Then, they think it will be more precise if they shift the line 7.6 units upward. They realize that their line is not quite fit yet. So, they modify the gradient of the line to be smaller, i.e. \( m = 0.92 \). Lastly, they restrict the domain to be \( \{ x \mid -9 \leq x \leq -1.75 \} \). The result of their works is shown on Figure 7.

However, her trials and refinements method in modelling the aspect of the picture has limitation. At least, this method requires a lot of repetition before she find the right model. Therefore, the teacher need introduce more efficient method. The method is based on finding the equation of a line when two points on the line
are given. Let the two points are \((x_1, y_1)\) and \((x_2, y_2)\) where \(x_1 < x_2\). Then, the gradient of the line is as follows.

\[
m = \frac{y_2 - y_1}{x_2 - x_1}
\]

whereas the \(y\)-intercept of the line can be determined by using this formula.

\[
c = y_1 - mx_1
\]

When the values of both of \(m\) and \(c\) are obtained, then the students have the equation of the line. In order to work more efficiently, students should pick those two points at the opposite ends of the line segment shown in the picture. In this way, the students also get the domain of the line, i.e. \(\{x \mid x_1 \leq x \leq x_2\}\). This method in finding the equation and the domain of a line can be translated into Desmos environment as shown in the Figure 8. The final Desmos graph can be accessed in https://www.desmos.com/calculator/kvmzuw2tsm.

![Figure 8](image1.png)

**Figure 8.** More efficient alternative method

In summary, students will apply various conceptual and procedural knowledge and understanding about linear function when performing Activity I in this chapter. As previously illustrated, they will use gradient and transformation of function concepts when they use trials and refinements method. In the latter method, the students are also required to know the procedures on finding the equation of a line when two points in the line are known. Therefore, this computational sketching activity has a potential in transforming students’ interest into mathematically rich task. If you need more ideas in designing this kind of activity, you can visit Desmos creative art website: https://www.desmos.com/art.
Activity II: Modelling the Growth of Processor Speeds

Does any of your students like to play video game? If any, we can use the video game context to teach them about exponential function. One of recommended teaching materials about this topic is provided by Mathalicious (see https://www.mathalicious.com/lessons/xbox-exponential). In their teaching materials, your students are asked to create a model prediction for the growth of verbal processor speeds and then compare the model with the actual growth. Next, we will adapt the Mathalicious’ teaching materials into the Desmos environment.

1. Start creating Desmos activities by using Desmos activity builder. You may choose “Growth of Processor Speeds” as your activities title.

2. We write the learning objectives on the first screen. The learning objectives are as follows:
   (a) Write an exponential function to a model a verbal prediction for the growth of processor speeds.
   (b) Describe how processor speeds have actually changed using an exponential model.

Therefore, the display of the first screen is as follows.

3. In second screen, we asked your students to interpret the statement from Gordon Moore regarding his prediction on the growth of processor speeds. So, we add Note and Table in this screen.
4. We ask your students to model the processor speeds as a function with respect to \( t \), the number of years that have passed since 1977, in third screen. We use Note and Input in doing so.

5. After your students have a prediction model of processor speeds based on Moore’s Law, now we asked them to find the actual model based on real data. Therefore, we ask them to research the processor speeds from Wikipedia in fourth screen.
6. In fifth screen, we asked your students to copy-paste the year \((x_1)\) and actual speed \((y_1)\) data from the previous screen into the table in Graph. When the table available, they can see the plotted points \((x_1, y_1)\). Then, we invite them to use regression in finding best fitted model for the plotted points. \textbf{Note:} In Desmos, you can type \(y_1 \sim ae^{bx}\) to find the best fit exponential model.

7. In last screen, we ask the students to compare the prediction model based on Moore’s Law and actual model. To do this we can use \textbf{Note} and \textbf{Input}.

Modelling activities that we just develop are expected to provoke students’ curiosity about the growth of processor speeds. Through the activities, students are required to use their reasoning to model Gordon Moore statement about how fast the processor speeds have change, then evaluate the model by using real data they collected from the internet. Therefore, these activities give environment for students to think critically and make data-based judgement.
Exercises

1. We have developed activities that ask students to sketch lines in Activity I. Create similar activities, but the goal is to enhance students’ understanding in sketching parabolic curves.

2. Find good teaching materials from the internet. Then, adapt the materials into interactive activities by utilizing Desmos activity builder.
Chapter V: Final Remarks

We have created various mathematical activities by using Desmos. Always remember that Desmos is just a tool to enhance the quality of students’ learning. This tool should be supported by well-planned mathematical tasks that are appropriate to students’ level and teacher’s readiness in implementing such tasks. In designing mathematical activities by using Desmos, teachers should keep in mind that the activities should stimulate students’ engagement. It means that the activities should keep students focus on the tasks, make them motivated in their learning, and invite them to active socially.

The activities developed in Desmos should have additional value as compared to the traditional method. That is, the Desmos activities must be built to develop more sophisticated understanding of a particular mathematics content. Aside of that, the Desmos activity will be effective if it offers scaffolding to ease the students in understanding mathematical concepts or ideas.

As illustrated in Chapter IV, Desmos activities can be intended to bridge their learning in school to their daily life. Icing on the cake, it will be good for students if they also can perform Desmos activity out of their classroom. Therefore, it is expected that the Desmos’ activities also can bridge students’ learning in school and their everyday life experiences.
References


