

Interactive electronic mathematics presentations for the classroom

Colleen Eddy, University of North Texas, Colleen.Eddy@unt.edu

Barba Patton, University of Houston-Victoria, pattonb@uhv.edu

Lei Ann Gimdt, Garndo Independent School District

Abstract

This article describes how teachers and researchers can create interactive electronic mathematics presentations (IEMPs) utilising presentation software, mathematical software and the Internet. The incorporation of dynamic technology provides an opportunity to seamlessly integrate mathematics with other content. This form of presentation engages students in making connections between mathematics and its application to real life. The article discusses the incorporation of technology such as the implementation of IEMPs in the classroom and its impact on student learning. It further discusses student data using IEMPs.

This article has been peer-reviewed and accepted for publication in *SLEID*, an international journal of scholarship and research that supports emerging scholars and the development of evidence-based practice in education.

© Copyright of articles is retained by authors. As an open access journal, articles are free to use, with proper attribution, in educational and other non-commercial settings.

ISSN 1832-2050

Introduction

As mathematics educators, making mathematics engaging and relevant for all students while ensuring its alignment with the National Council of Teacher of Mathematics (NCTM) *Principles and Standards for School Mathematics* (PSSM) (NCTM, 2000) is our primary goal. PowerPoint is one of the technology presentation tools to be incorporated in the classroom. A PowerPoint presentation embedded with interactive tools connects the content with the technology that students are using to learn the mathematics. Some of these interactive tools include dynamic mathematics software such as Cabri 3D (Cabrilog, 2007) and Geometer's Sketchpad (Key Curriculum Press, 2009), and links to the Internet such as Illuminations (NCTM, 2008) and The National Library of Virtual Manipulatives (Utah State University, 2008). The utilisation of available technology makes it possible to integrate content more seamlessly and engage students in the learning of mathematics. For the purposes of this article, an example of an interactive electronic mathematics presentation (IEMP) incorporates a mathematical concept, a literature connection, and an instructional activity.

Components

The four basic components of an IEMP include a mathematical concept, interactive technology, PowerPoint slides, and a hands-on activity. The mathematical concept focuses on one central idea but is also used to reinforce other mathematical concepts. The interactive technology used in the IEMP includes the incorporation

of dynamic software and Internet resources. Dynamic software such as Geometer's Sketchpad (Key Curriculum Press, 2009) and Cabri 3D (Cabrilog, 2007) allow constructions to be imported directly into the IEMP. Users of shared IEMPs who do not have the software are able to download the plug-in for manipulating the figure within the slide show. Internet resources such as the National Library of Virtual Manipulatives (Utah State University, 2008) and Illuminations (NCTM, 2008) provide semi-concrete demonstrations for many mathematical concepts on many different levels. For example, there are demonstrations on fractions for the beginning (pre-kindergarten) to the advanced (high school) student.

The IEMPs support the technology principle from the PSSM (NCTM, 2000), which states "technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning" (p. 11). Furthermore the IEMPs are supported by the "planning and designing learning environments and experiences" and "teaching, learning, and the curriculum" from the *National Educational Technology Standards (NETS) and Performance Indicators for Teachers* (International Society for Technology in Education, 2000).

The IEMP provides a smooth transition between the abstract and the hands-on experiences by logically guiding students through the mathematical concept that is derived from the hands-on activity. The activity is the event that engages the student in the mathematics that is emphasised in the IEMP. The students are provided directions in the PowerPoint slides thus freeing the teacher to spend time guiding students in their learning of the mathematics.

The IEMP lesson described in the following paragraphs was created for Algebra I students titled "Linear equations, graphs, tables, and descriptions – Oh My!" This lesson and the IEMP along with other lessons and IEMPs for Algebra can be found at www.coe.unt.edu/algebra/ (Eddy et al., 2008).

Subjects

Eighth grade students in a small public school in Texas were the subjects. There were ten boys and one girl in the class. A majority (72%) of the students were of minority ethnicity and low socioeconomic status. In Texas, if students do not pass the state achievement tests in the fifth and eighth grades, they will not be promoted to the middle or high school. These state tests include reading, writing, math, and science. If the students do not pass all four of these tests, they are required to repeat that grade. The eleven subjects in this study were in a class which was designed to provide more focus on these academic areas with the objective of helping each student pass all parts of the test. The teacher and researcher collaborated prior to the teacher teaching the lesson. The researcher observed the students during the lesson.

Engage

The mathematics objective in the IEMP lesson was for the students to translate linear relationships into algebraic, graphical, and tabular forms. As an introduction to the lesson and to help the students feel comfortable working with the researcher, the students were presented the work of M. C. Escher which contained several patterns. Some of the patterns were very obvious while others were less obvious. The students seemed to be at ease and did not show any anxiety toward the upcoming work. Many of Escher's art works have tessellations with varied patterns within the work. The students listed all patterns they noticed in the Escher

art works as they worked in groups of two. There was one group of three. Students shared the patterns they found with the class by listing them on the board. This portion of the lesson provided a common experience for all students on which to base the lesson. An extension could be having students share other patterns they have noticed in other contexts and in their everyday lives.

The first slide in the IEMP displayed the mathematical objective with successive slides guiding students through the mathematics (Figure 1). In this IEMP, the teacher displayed a short description of Escher's work and then clicked on the link to open the Escher drawing that was available free online (Figure 2).

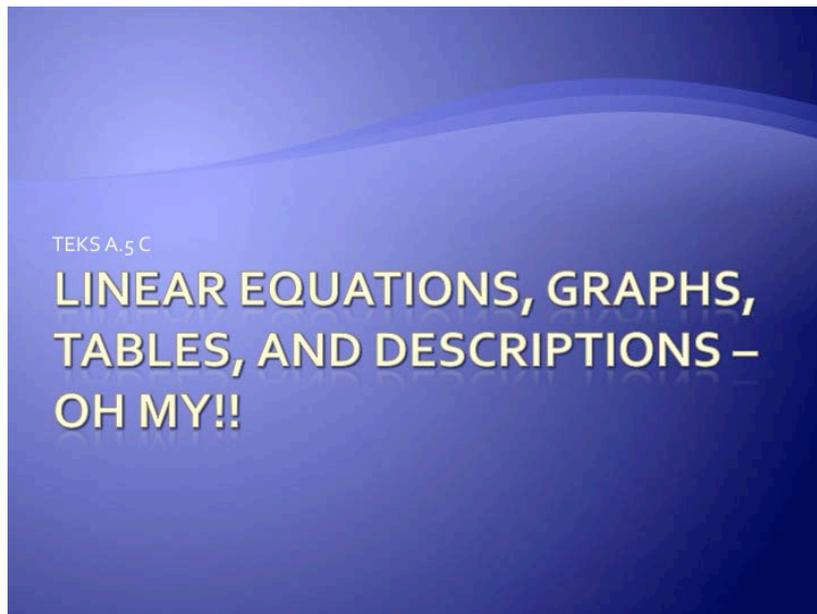


Figure 1: First slide of the IEMP describes the mathematical objective

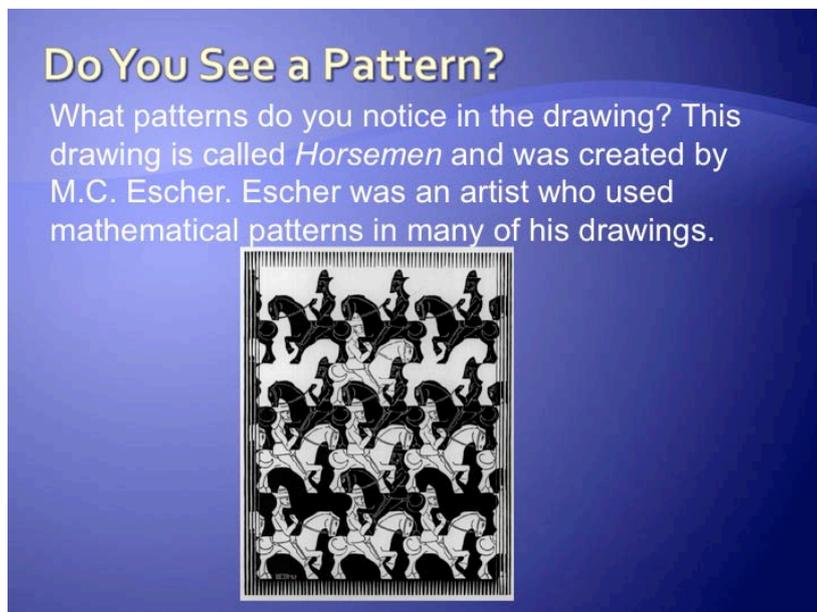


Figure 2: Second slide of the IEMP. Escher art retrieved from http://amicojoe.altervista.org/escher/page_02.htm

Students identified patterns in Escher's "Horsemen." Some of the horses are going to the right and some are going to the left; some are black and some are not; and

some have details drawn in (i.e., reins) while others do not. All students were in agreement with the identified patterns as all had identified them prior the groups listing them on the board. There was not one comment such as, “Oh now I see it” or “I did not see that one.”

Explore

Students were given colour tiles to create the pattern shown in slide 3 (Figure 3). Although we used the colour tiles, you could use any type of square pattern shapes which you have readily available. Students completed the activity sheet that corresponded with the slide (Appendix A). Students worked in their groups to develop the representation of the pattern in a table and identify whether the pattern was linear. Students wrote an explanation of their response. Having both the IEMP and the activity sheet prevented the need to flip back and forth between documents thus enabling the teacher greater opportunity to facilitate student learning. The activity was debriefed using the IEMP, which included the tabular, algebraic and graphical representations of the pattern (Figure 4). Students were able to connect their work with the IEMP and engage in the class conversation about the pattern being linear and a function.

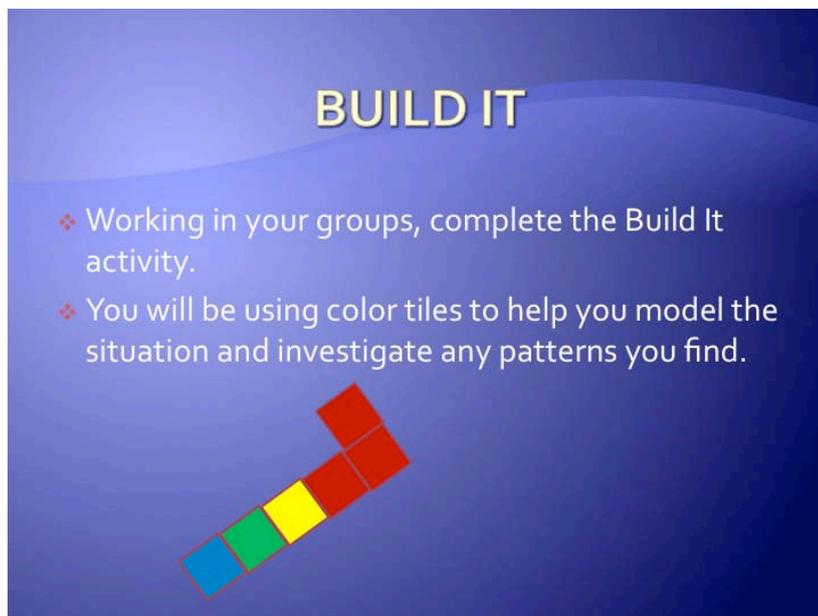


Figure 3: Students building a pattern

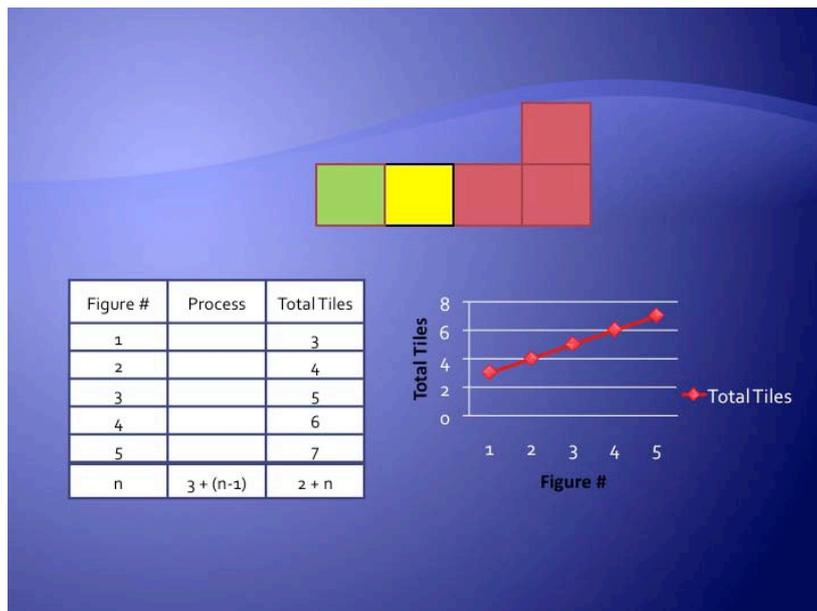


Figure 4: Debrief of the pattern

Students reported that they thought this was a fun way to learn mathematics. All the students were able to continue the pattern with the manipulatives. Question 2 (Appendix A) asked *Based on the table you completed above, would this be an example of a linear relationship? Explain.* All of the students agreed that it was a linear relationship but only two could give a correct explanation. The two who did answer with a correct explanation stated that the word ‘line’ is in linear so they believed that it was a linear relationship. However, when asked to complete question 3, *Would this be an example of a function? Explain,* students did not have a clear understanding of a function and did not answer the question. There was much discussion in the groups but no one mentioned domain, range, etc.

Next, students reviewed several ways to represent a pattern. They were challenged to use the blocks to build a model patio. The problem was first viewed as a class. Students then worked in their groups to explore the pattern using the activity sheet (Figure 5 and Appendix B).

PATHS FROM A PATIO

Jill has a beautiful patio made of bricks in the center of her yard. The patio is a 3 by 2 rectangle of bricks. Getting to the patio was difficult when it rained because the yard got so wet. She decided to build paths from her patio using the same bricks used when she designed the patio. Each day she brought in more bricks.

Within your group, investigate and analyze this situation using the Activity Sheet.

Figure 5: The patio problem

Explain

The teacher used conversations from the groups during the explore portion of the lesson to reinforce student understanding of the mathematical concept of patterns during the explain portion of the lesson. The IEMP allowed the teacher to emphasise different representations of the same pattern and how each provided insight into whether each pattern was linear and a function (Figure 6). The teacher facilitated students making these connections. The use of the IEMP made it possible for the teacher to toggle between the results of the two patterns incorporated in one slide show to reinforce the linear relationship of each pattern rather than deal with multiple papers or transparencies (Figures 4 and 6).

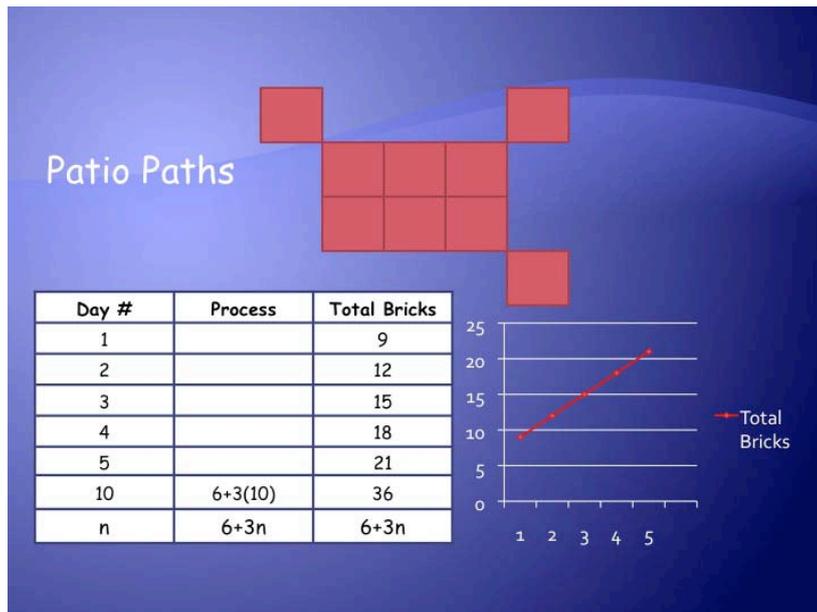


Figure 6: Patio pattern debrief

The students did not have any difficulties completing the pattern. On this question, other students quickly interjected that it was a linear relation. They agreed that it was a line so it had to be a linear relationship. The students did not offer any other explanations for their answers.

Question 3 (Appendix B) asked students to graph the information from the table on the coordinate plane. Students were able to graph the information correctly. When students were asked, *Does the graph of your data represent a linear function? How can you tell?*, the students responded that the data did represent a linear function because it was a line.

Next, the students were asked, *Describe the domain and range for this situation*. None of the students responded nor seemed to understand the terms even when probing questions were posed. The researcher noted that the teacher was not able to determine if the students had been exposed to the use of other words when working with the domain and range and provided an explanation of the terms in context of the problem. The students were able to complete the table quickly. When asked, *How many bricks would there be on the 20th day?*, the students were quick to respond with the correct answer of 66. They were equally quick to explain the algebraic expression, which justified their response.

Also, given the following: *Using your table, write a rule using function notation to determine the number of bricks on the n^{th} day*, the students were able to write a correct rule for this activity. When asked to *Write a description of how your rule is related to the brick picture. Include a description of what is constant and what is changing as bricks are added*, all of the students were able to describe how their rule related to the picture and described what changed as additional bricks were added.

To additional questions such as *Would there be a day in this set that uses 39 bricks? 59 bricks? Explain your reasoning*, the students responded that on the 11th day, there would be 39 bricks used, but there would not be a day that they would use exactly 59 bricks if the pattern were completed. The students had many solutions as to the use of just 59 bricks, which left the pattern incomplete for the specific day. They stated that on the 17th day, they would have $6+3(17)$, which would equal 57 bricks, but on the 18th day they would need $6+3(18)$ which would equal 60 bricks.

Elaborate

The students were given another pattern to build. This pattern was more complex since it was three-dimensional. The activity sheet provided a description and visual of the building the bathtub with snap cubes (Appendix C). Students were supplied with the snap cubes to create the bathtub (Figure 7). The teacher used the IEMP with the three dimensional (3D) figure (Figure 8). The researcher observed that the teacher was able to manipulate the figure so students were able to see the different layers of the pattern. Students who were seated in the back of the classroom had the same access to the figure as students in the front of the classroom.

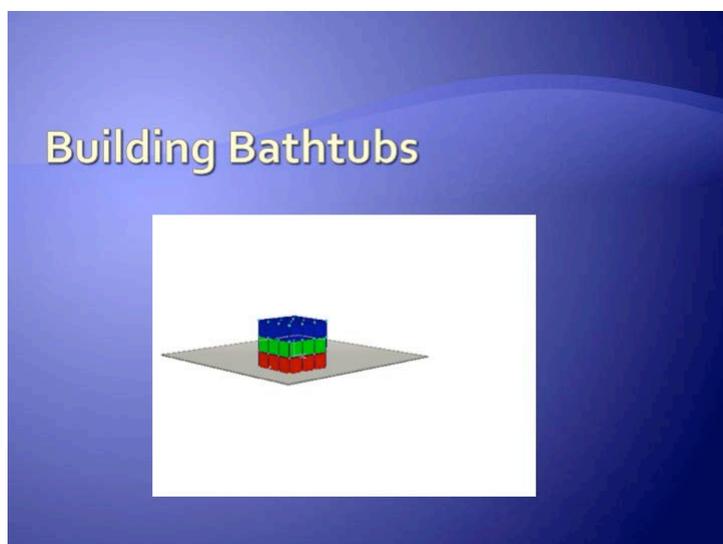


Figure 7: Manipulative 3D figure



Figure 8: Student created bathtub

The interactive software used in this IEMP was Cabri 3D. By right clicking and holding the button down on the mouse, the teacher was able to move the figure within the slide show during the discussion. This allowed an enlarged view of the manipulatives that students had in front of them so that all students were visually able to see what was being discussed. The researcher noted the teacher used a laser pointer or the cursor arrow to emphasise aspects of the pattern.

The teacher created the figure in this presentation with available software; however, the computers utilised for presenting the mathematics lessons do not have the mathematical software available. By downloading the plug-in (<http://www.cabri.com/download-cabri-3d.html>) one is not limited to the same system in which the interactive figure was created.

The first task the students were asked to complete was the table to help organise the data in calculating the total number of blocks Bob used in his bathtub design each day (Figure 9). The students were able to complete the task quickly. When asked the following questions that corresponded to the problem, their responses were much like those to previous questions. To the question *Does the information in this table represent a linear function? How can you tell?* the students responded it was a linear function because it was a line. This time however, students had difficulty graphing the information from the table even when the teacher asked facilitating questions that related to previous problems within the lesson.

Table 1: Completed table for the bathtub problem

Day #	Process	Total Blocks
1	Base + edges $9 + 8$	17
2	$9+8+8$	25
3	$9+8+8+8$	33
4	$9+8+8+8+8$	41
5	$9+8+8+8+8+8$	47
10	$9+ 8(10)$	89
n	$9 +8(n)$	

Students developed the rule to explain their choices on the first steps of the table and then were able to quickly determine that on the 20th day they would need 161 blocks. Students stated that they knew that the bottom was 9 cubes, and then 8 more added to make the bathtub. On the second day and each day thereafter, an additional 8 cubes were added. The rule was determined to be $9+8(n)$.

Evaluate

The researcher noted that the teacher monitored and assessed student learning during the entire lesson. The researcher noted the IEMP facilitated the teacher by organising the lesson thus enabling the teacher to facilitate students to make connections between the representations of the pattern and linear functions. Students were evaluated by the creation of their own bathtub pattern and representations (Appendix D).

Each group of students was successful in building their own bathtub. Their drawings correctly represented the group's desired dimensions. A couple of the students wanted to make a smaller bathtub but quickly found that it was not possible. The bathtub had to have at least 3×3 base in order to have space to sit in the tub.

All of the students were able to make connections between their bathtub creation, the table, and the function rule. Only one student was able to correctly make connections with the bathtub creation, the table, the function rule and *the graph*. The lesson was meant to reinforce the concepts of domain and range learned previously but the teacher realised that the concept needed to be revisited as the focus. The teacher determined from this evaluation that students needed additional instruction on domain, range, and graphing.

Impact on Student Learning

The teachers who used IEMPs to enhance the mathematical instruction in the classroom have indicated that students are more engaged in learning. Students' learning was scaffolded during the lesson so that students at all ability levels had access to the concepts. Students were encouraged and facilitated during the lesson and provided opportunities to participate in small group and whole class discussions.

The IEMP allowed students to focus on the mathematics. For example, students had a difficult time understanding how the bathtub was built from the description and figures provided on the activity sheet. The IEMP provided a 3D figure where all students could see the figure at different views (Appendix C).

IEMPs assisted the students in connecting the concrete and abstract. The patterns in the IEMP are similar to the patterns students created with concrete manipulatives. The electronic forms of the pattern provide a semi-concrete representation of the pattern.

Discussion

There are several lessons in creating and implementing IEMPs that have been learned over time. These include creating interactive images, incorporating interactive links, one place for lesson components, and the simplicity of creating an

IEMP. Creating interactive images are best made within programs such as Cabri 3D and Geometer's Sketchpad and saving the figure when satisfied with the result. Importing figures into PowerPoint requires a right click on the mouse, selecting the mathematics program (i.e., Cabri 3: Active Document Object) and then selecting import. Import brings up the browser where the saved image is selected from your files. One must have the mathematical programs in order to create and import figures when creating IEMPs. If IEMPs are shared such as the one with this article, then only the free plug-in (<http://www.cabri.com/download-cabri-3d.html>) is necessary in order to access the interactive figures.

Incorporating links to websites, which are interactive (i.e., illuminations, National Library of Virtual Manipulatives) requires selecting the hyperlink within PowerPoint once the text is selected or the web address has been typed. Input the web address if not included on the hyperlink screen. Check hyperlinks periodically when using an IEMP with them because web addresses might have become inactive.

One of the benefits of creating IEMPs is that all the components for the teacher-led portion of the instruction are in one place. In addition, an IEMP is easy to edit and requires little memory space as opposed to physical space required by hard copies.

IEMPs do not require elaborate graphics, text, or sound to be effective. With as little as 8-15 PowerPoint slides (this includes slides that have figures appearing one at a time) you can create an interactive IEMP that will enhance the mathematical instruction for your students. IEMPs are also fun to create with other teachers in mathematics and other disciplines.

Interactive Electronic Mathematics Presentations (IEMPs) have the potential to be most effective when used in the classrooms. The advantages they provide can possibly limit some of the misunderstandings, which students seem to gather when taught in other formats that do not include visual representations. Bell, Brekke, and Swan (1987b, p. 56) espouse, "where serious errors exist they cannot be removed simply by teaching the correct idea." With this in mind, it is imperative that students have every advantage possible to master concepts without any misunderstanding in the initial instruction.

References

- Bell, A., Brekke, G., & Swan, M. (1987a), Diagnostic teaching: Five graphical interpretation teaching styles and their effects. *Mathematics Teaching*. 120, 50–57.
- Bell, A., Brekke, G., & Swan, M. (1987b), Diagnostic teaching: Four graphical interpretations. *Mathematics Teaching*. 119, 56–60,
- Cabrilog. (2007). Cabri 3D (Version 2.0) [Computer software]. Grenoble, France: Cabrilog SAS.
- Eddy, C., Richardson, C., Hughes, K., & Slavens, D. (2008). XTreem mathematics: Teaching Algebra I. Retrieved from the University of North Texas, College of Education website: <http://www.coe.unt.edu/algebra/>

- International Society for Technology in Education. (2000). *ISTE National Educational Technology Standards (NETS) and Performance Indicators for Teachers*, Retrieved from <http://www.iste.org>
- Key Curriculum Press. (2009). *The Geometer's Sketchpad (Version 5.0)* [Computer software]. Emeryville, CA: Key Curriculum Press.
- National Council of Teachers of Mathematics. (2008). *Illuminations*. The National Council of Teachers of Mathematics. Retrieved from <http://illuminations.nctm.org>
- National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: The National Council of Teacher of Mathematics.
- Utah State University. (2008). *National library of virtual manipulatives*. Utah State University. Retrieved from <http://nlvm.usu.edu/en/nav/vlibrary.html>

Appendix A

Build It

Using colour tiles, build the following figures.



Figure 1



Figure 2

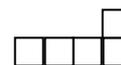


Figure 3

1. How many tiles are in each figure? How many tiles will be needed to build the next figures? Use the following table to help you organize your data.

Figure #	Process	Total Tiles
1		
2		
3		
4		
5		

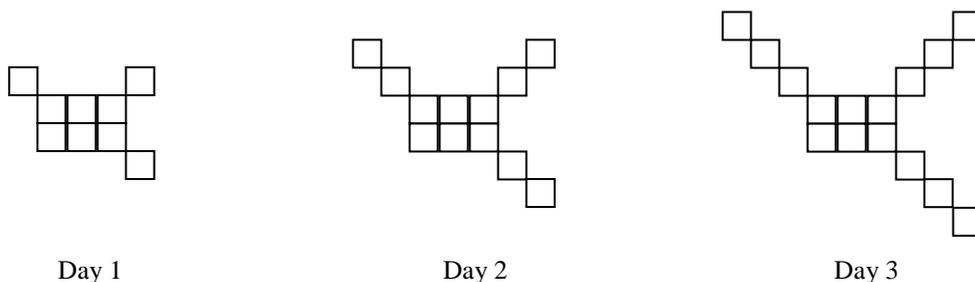
2.
 - a. Based on the table you completed above, would this be an example of a linear relationship? Explain.

3. Would this be an example of a function? Why or Why not?

Appendix B

Paths from the Patio

Jill had a beautiful patio made of bricks in the centre of her yard. The patio was a 3 by 2 rectangle of bricks. Getting to the patio was difficult when it rained because the yard got so wet. She decided to build paths from her patio using the same bricks used when she designed the patio. Each day she brought in more bricks.

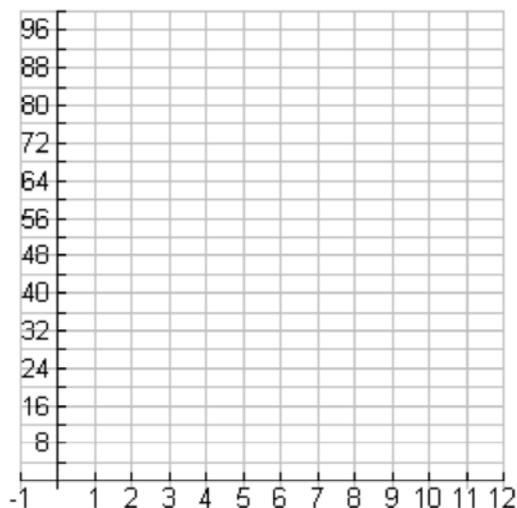


- Complete the following table to organize your data in calculating the total number of bricks Jill has in her design each day.

Day #	Process	Total Bricks
1		
2		
3		
4		
5		
10		
n		

- Does the information in this table represent a linear function? How can you tell?

3. Graph the information from the table on the coordinate plane below.



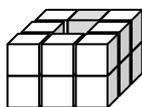
- 4.
- Does the graph of your data represent a linear function? How can you tell?
 - Describe the domain and range for this situation.
5. How many bricks would there be on the 20th day? Justify your response?
6. Using your table, write a rule using function notation to determine the number of bricks on the n^{th} day.
7. Write a description of how your rule is related to the brick picture. Include a description of what is constant and what is changing as bricks are added.
8. Would there be a day in this set that uses 39 bricks? 59 bricks? Explain your reasoning.

Appendix C

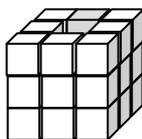
Building Bathtubs – Part I

Bob is building a basic bathtub out of blocks. The first figure shows the bathtub with nine blocks in the bottom layer and eight blocks in the second layer. It has a bathing space inside of one cube. Using your cubes, make the basic bathtub shown in the figure.

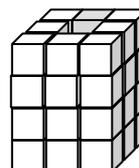
- Bob decides he wants to make the tub taller. Each day Bob adds another layer to the top of his tub as shown in the second and third example. Try building these models with your cubes.
- At the end of each day, how many blocks has Bob used?



Day 1



Day 2



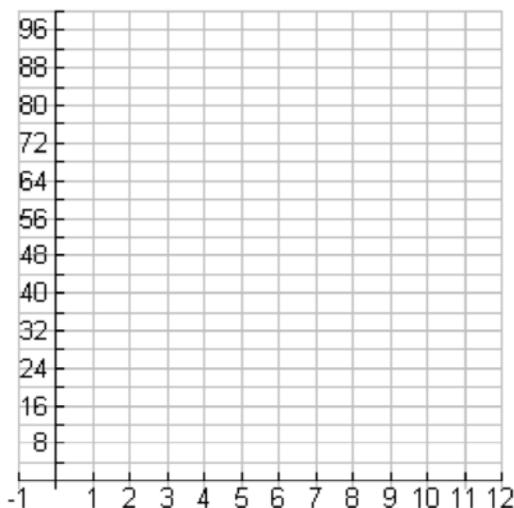
Day 3

1. Complete the following table to help you organize your data in calculating the number total number of blocks Bob has in his bathtub design each day.

Day #	Process	Total Blocks
1		
2		
3		
4		
5		
10		
n		

2. Does the information in this table represent a linear function? How can you tell?

3. Graph the information from the table on the coordinate plane below.



- 4.
- Does the graph of your data represent a linear function? How can you tell?
 - Identify the domain and range.
5. How many blocks would there be on the 20th day? Justify your response?
6. Using your table, develop a rule to determine the number of blocks on the n^{th} day.
7. Write a description of how your rule is related to the brick picture. Include a description of what is constant and what is changing as blocks are added.
8. Would there be a day in this set that uses 59 blocks? Explain your reasoning.

Appendix D

Building Bathtubs – Part II

Now it is your turn. Using the blocks you have been given, construct a bathtub of your own design that would model a linear function.

1. Give a verbal description of your model similar to the previous Building Bathtubs activity.
2. Draw a 3-dimensional view of your bathtub model for the first, second and third time periods.
3. Complete a table showing the values for at least 6 time periods.
4. Complete a graph showing your model.
5. Write a function rule to represent the model that you created. Be sure to describe the domain and range of your function.

