Performance Based Learning and Assessment Task

Modeling the Number of Starbucks Stores

I. ASSESSSMENT TASK OVERVIEW & PURPOSE:

In this activity, students will determine the type of model that best fits a set of data, find the equation for this model, and use it to make predictions.

II. UNIT AUTHOR:

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III. COURSE:

Algebra, Functions, and Data Analysis

IV. CONTENT STRAND:

Algebra and Functions

V. OBJECTIVES:

Students will be able to determine the type of model that best fits a set of data, find the equation for this model, and use it to make predictions. They will also be able to analyze the effectiveness of the model within the context of the problem and consider how a different model can be obtained by changing the data.

VI. REFERENCE/RESOURCE MATERIALS:

Materials include copies of the "Modeling the Number of Starbucks Stores" activity sheet, graphing calculators, and a Smart Board or whiteboard.

VII. PRIMARY ASSESSMENT STRATEGIES:

Students will be assessed on their ability to correctly identify the type of model that best fits a set of data, find the equation, and use it to make predictions. They will be required to show their calculations and provide explanations.

VIII. EVALUATION CRITERIA:

An assessment list and a benchmark of exemplary work for the activity are included in this packet.

IX. INSTRUCTIONAL TIME:

This activity is intended to take about one 90-minute block or two 45-minute periods.

Modeling the Number of Starbucks Stores

Strand
Algebra, Functions, and Data Analysis – Algebra and Functions

Mathematical Objective(s)
Students will be able to determine the type of model that best fits a set of data, find the equation for this model, and use it to make predictions. They will also be able to analyze the effectiveness of the model within the context of the problem and consider how a different model can be obtained by changing the data.

Related SOL
AFDA.3 (collect data and generate equation for the curve of best fit to model real-world applications)

NCTM Standards
- For bivariate measurement data, be able to display a scatterplot, describe its shape, and determine regression coefficients, regression equations, and correlation coefficients using technological tools
- Communicate mathematical thinking coherently and clearly to peers, teachers, and others

Materials/Resources
- Copies of the "Modeling the Number of Starbucks Stores" activity sheet
- Graphing calculators
- Smart Board/Whiteboard

Assumption of Prior Knowledge
- Students should know how to use a graphing calculator to enter data, make a scatter plot, and perform regressions. They should be familiar with quadratic functions and know how to determine when this type of function best fits a set of data. They should also know how to use a regression equation to make predictions and will have experience modeling data using a table.
- Students should understand independent and dependent variables.
- Students will hopefully realize in completing this activity that no equation is perfect in modeling a set of data and that there is always a degree of error. They should also see how data can be manipulated to produce different results, such as considering only a subset of the data.
- When entering the data in their calculator, some students may make the error of confusing the x- and y-variables.

Introduction: Setting Up the Mathematical Task

- This task is intended to take about one 90-minute block or two 45-minute periods.
- The teacher will introduce the activity by asking students if they enjoy going to Starbucks and having them guess how many stores existed in their first year and how many exist now. The teacher will explain to students that they will be using real data to determine an equation that will allow them to predict the number of Starbucks stores that will exist in the future.
- For the "Modeling the Number of Starbucks Stores" activity, students will be divided into groups of two or three (preferably with a mixture of low- and high-ability students). This will allow them to discuss their thinking with others, giving the low-ability students extra help and providing the high-ability students an opportunity to enhance their mathematical communication skills.
- Students will be told that the activity is open-ended in that there are multiple ways to approach each problem. As long as they address the question at hand and provide sufficient evidence to support their answer, they will be successful. They will be encouraged to discuss possible strategies for solving each problem with their group members.

Student Exploration

- Students will work with their group members to complete the "Modeling the Number of Starbucks Stores" activity. Students will be given data on the number of Starbucks stores from 1987 to 2014 and be asked to do the following:
  Graph the data and find the model that best fits this data. Use your model to predict the number of stores within this time frame and for the future. Explain your model and graph. Discuss your model as a predictor.
  The teacher will rotate around the room, checking in with each group to answer/ask questions in order to facilitate learning.
- The teacher may ask the following questions to promote student thinking:
  - Why is the type of model you chose a better fit than any others?
  - How does the graph of the data help you understand the rate at which the number of stores has increased? (*Has* the number of stores always increased?)
- The following is a possible error students may make and questions that can be used to address it:
  - They may get the x- and y-variables confused. (What are the independent and dependent variables? Which one is the x and which is the y?)

Monitoring Student Responses

- Students will communicate with their group members during the activity. They will be required to explain their thinking as they answer the questions on the activity sheet.
- The teacher will rotate amongst the groups to be sure each group is on the correct path. If a student or group is having difficulties, the teacher can ask questions to help clarify the material. If the teacher notices that multiple groups are having trouble with the same thing, he/she may bring the class together to discuss the issue. Either the teacher can provide some guidance, or he/she can call on a student who understands it to explain his/her thinking to the class.
- When all groups have completed the activity, the teacher will bring the class together to discuss their results. An emphasis will be placed on the different strategies students used to solve the problems. Student volunteers from each group will be given the opportunity to share their group's strategy with the class.

Assessment List and Benchmarks

- The assessment list and a benchmark of exemplary work for the activity are included in this packet.

Modeling the Number of Starbucks Stores

The table below shows the number of Starbucks stores from 1987 to 2014, as reported on the company website:

Year	Number of Stores
1987	17
1988	33
1989	55
1990	84
1991	116
1992	165
1993	272
1994	425
1995	677
1996	1015
1997	1412
1998	1886
1999	2498
2000	3501

Year	Number of Stores
2001	4709
2002	5886
2003	7225
2004	8569
2005	10241
2006	12440
2007	15011
2008	16680
2009	16635
2010	16858
2011	17003
2012	18066
2013	19767
2014	20519

Data retrieved from
http://globalassets.starbucks.com/assets/5deaa36b7f454011a8597d271f552106.pdf

1. Graph the data and find the model that best fits this data. Use your model to predict the number of stores within this time frame and for the future. Explain your model and graph. Discuss your model as a predictor.

2. Identify a series of 3-4 years in which the model you identified in #1 predicts values that differ greatly from the actual data. Explain the discrepancy based upon the meaning of the data points within the context of the problem.

3. Suggest a way that one might obtain a different type of model by considering only part of the data. Provide the data you have chosen, the type of model, and the equation for the model. Compare the predictions from this model to the ones obtained in #1.

Assessment List

			Earned Assessment	
Number	Element	Point Value	Self	Teacher
1	A graphical representation is provided.	2		
2	An appropriate type of model is identified.	2		
3	Appropriate predictions within the time frame and for the future are provided.	2		
4	Explanations of the model and graph are provided.	2		
5	A discussion of the model as a predictor is provided.	2		
6	An appropriate series of years during which the model differs is identified.	2		
7	An explanation is provided.	2		
8	A set of data that produces a different type of model and the type of model are identified.	2		
9	An appropriate equation is provided.	2		
10	An appropriate prediction and comparison are provided.	2		
11	The work is neat and presentable.	2		

Rubric

Number	Element	0	1	2
1	A graphical representation is provided.	No graphical representation or an inappropriate graphical representation is provided.	A partially appropriate graphical representation is provided.	An appropriate graphical representation is provided.
2	An appropriate type of model is identified.	No type of model is identified.	An inappropriate type of model is identified.	An appropriate type of model is identified.
3	Appropriate predictions within the time frame and for the future are provided.	No predictions or inappropriate predictions are provided.	Incomplete or partially appropriate predictions are provided.	Appropriate predictions within the time frame and for the future are provided.
4	Explanations of the model and graph are provided.	No explanations or inappropriate explanations are provided.	Incomplete or partially appropriate explanations are provided.	Appropriate explanations of the model and graph are provided.
5	A discussion of the model as a predictor is provided.	No discussion or an inappropriate discussion is provided.	An incomplete or partially appropriate discussion is provided.	An appropriate discussion of the model as a predictor is provided.
6	An appropriate series of years during which the model differs is identified.	No series of years or an inappropriate series of years is identified.	A partially appropriate series of years is identified.	An appropriate series of years is identified.
7	An explanation is provided.	No explanation or an inappropriate explanation is provided.	An incomplete or partially appropriate explanation is provided.	An appropriate explanation is provided.
8	A set of data that produces a different type of model and the type of model are identified.	No set of data or type of model are identified, or	An incomplete or partially appropriate set of data and	An appropriate set of data and type of model are identified.

		the answers are inappropriate.	type of model are identified.	
9	An appropriate equation is provided.	No equation or an inappropriate equation is provided.	A partially appropriate equation is provided.	An appropriate equation is provided.
10	An appropriate prediction and comparison are provided.	No prediction and comparison is provided, or the answers are inappropriate.	An incomplete or partially appropriate prediction and comparison are provided.	An appropriate prediction and comparison are provided.
11	The work is neat and presentable.	The work lacks neatness.	The work needs improvement.	The work is neat and presentable.