Bar of Soap

ID: XXXX

Time required
45 minutes

Activity Overview

In this activity, students investigate the decay over a three-week period of a bar of soap. While a quadratic model was hypothesised initially, the data over most of the period was surprisingly linear. Students explore, analyse and interpret the data provided using a variety of statistical tools and methods.

Concepts

- *Data organisation and display, regression, residuals and interpretation.*

Teacher Preparation

This investigation offers opportunities for students to explore a set of data using a variety of statistical tools and methods, with a particular focus upon regression and residuals. As such, care should be taken to provide ample time for ALL students to engage actively with the requirements of the task, allowing some who may have missed aspects of earlier work the opportunity to build new and deeper understanding.

- *This activity can serve to consolidate earlier work on data analysis. It offers a suitable introduction to further study of regression methods and residuals.*
- *Begin by discussing how students' own experiences and assumptions regarding the decay of a bar of soap over time.*
- *The screenshots on pages X–X (top) demonstrate expected student results. Refer to the screenshots on page X (bottom) for a preview of the student .tns file.*
- ***To download the .tns file, go to http://education.ti.com/exchange and enter "XXXX" in the search box.***

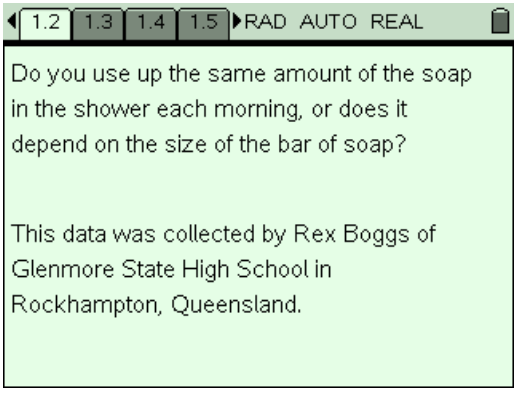
Classroom Management

- *This activity is intended to be **student-centered.** You should seat your students in pairs so they can work cooperatively on their handhelds. Use the following pages to present the material to the class and encourage discussion. Students will explore using their handhelds; the majority of the ideas and concepts are presented in their **TI-Nspire** document; be sure to cover all the material necessary for students' total comprehension.*
- *Students can either record their answers on the handheld or you may wish to have the class record their answers on a separate sheet of paper.*

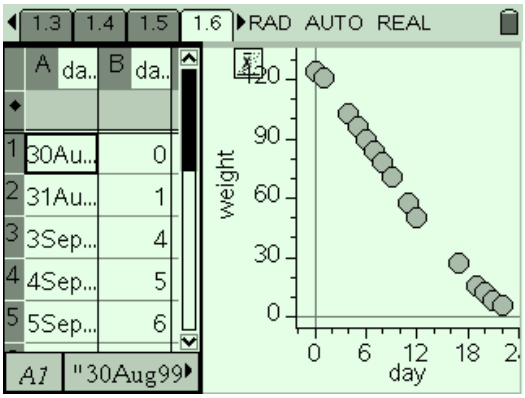
TI-Nspire™ Applications

Graphs & Geometry, Notes, Calculator

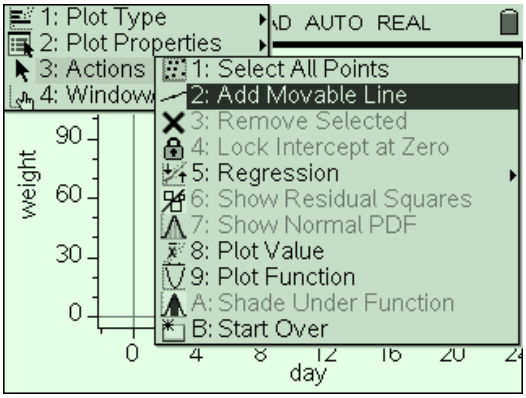
Step 1: Students should be encouraged to share what they believe concerning the way that a bar of soap will wear over time, and discuss ways in which they might test their ideas. The collected data may serve as a starting point for students to go on and collect their own data.



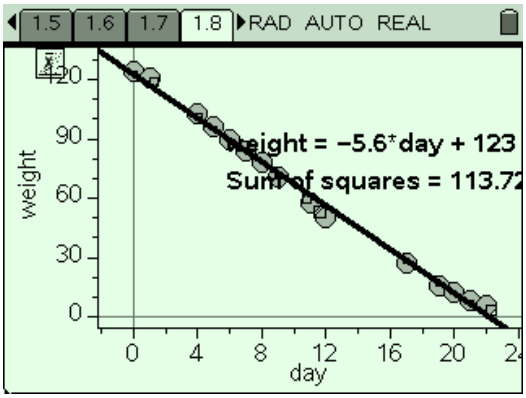
Step 2: Students should first discuss their interpretation of the numerical data, and then use the **Quick Graph** facility to view and discuss the plot of this data. It is important that informal attempts at interpretation are made at this stage, as the students come up with ideas and theories concerning the physical phenomena associated with the data.



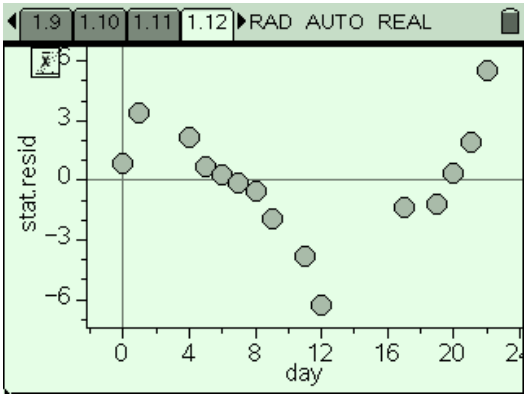
Step 3: The **movable line** facility is an important way for students to physically get a feel for the data, and allows an element of challenge, as students compete in their attempts to find the line which offers the least sum of squares – i.e. the line of best fit. The **Show Residual Squares** option supports this well.



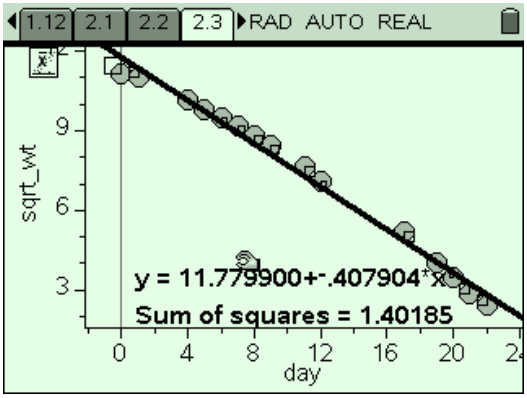
Step 4: After manually attempting to find their own lines of best fit, students should then be encouraged to compare and contrast the formal regression procedures, and to attempt some critique of these. While a median-median line will be less affected by outliers (where they exist), in this case the standard linear regression gives a slightly better result – perhaps due to an averaging effect of the "errors" at each end of the data?



Step 5: After carrying out the statistical regression procedure using **Lists & Spreadsheet**, students may easily view the residual plot and observe a strong pattern for the linear model. They should then be asked to conjecture the likelihood of a better model and to justify their choice. The quadratic model appears well chosen: least-squares regression on days vs the square root of weight gives an amazingly small result, and the residual range is similarly smaller than for the linear model.

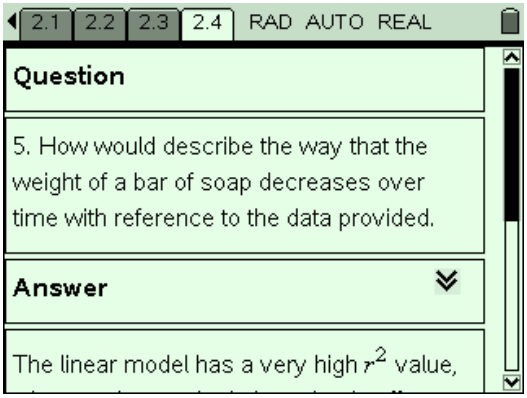


Step 6: Finally students should be encouraged to "put it all together" – recommend a "best regression model", justify their recommendation and then carefully describe the physical situation in their own words using what they have learned from their statistical analysis.



EXTENSION

Students may be encouraged to gather their own data and perhaps pool this in order to get a more viable data set and draw further conslusions.



Bar of Soap – ID: XXXX

(Student)TI-Nspire File: *StatActXX_Bar_of_Soap_EN.tns*

Bar of Soap

Statistics

Keywords: linear regression, residuals

Do you use up the same amount of the soap in the shower each morning, or does it depend on the size of the bar of soap?

This data was collected by Rex Boggs of Glenmore State High School in Rockhampton, Queensland.

"I had a hypothesis that the daily weight of my bar of soap in my shower wasn't a linear function, the reason being that the tiny little bar of soap at the end of its life seemed to hang around for just about ever. I wanted to throw it out, but I felt I shouldn't do so until it became unusable. And that seemed to take weeks."

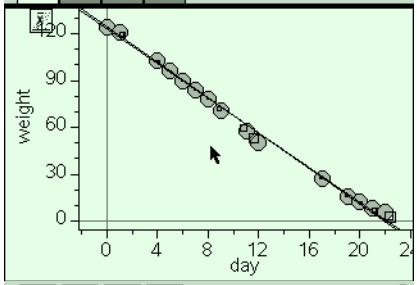
"Also I had recently bought some digital kitchen scales and felt I needed to use them to justify the cost. I hypothesised that the daily weight of a bar of soap might be dependent upon surface area, and hence would be a quadratic function."

"I kept records for three weeks (the life of the bar), and was amazed to find that the data was linear with a very high r^2 value, until the last few days of its life."

"The data ends at day 22. On day 23 the soap broke into two pieces and one piece went down the plughole ..."

	A da..	B da..	C we.	D	E	F	G
1	30Au...	0	124				
2	31Au...	1	121				
3	3Sep...	4	103				
4	4Sep...	5	96				
5	5Sep...	6	90				

A1 "30Aug99"



Question

2. Which regression model would you predict should give a better result for this data: **linear** (such as **a*x+b**) or **median–median**? Why?

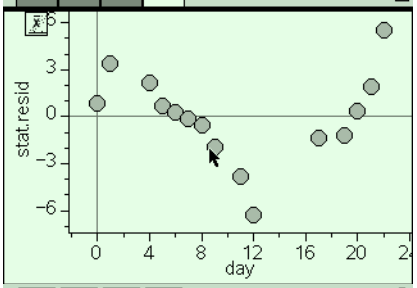
Answer

Question

3. Use the data values on the next page to compute a linear regression, and then plot the residual values against "day" on the D&S page following. What do these residual values tell you about this regression method?

	A da	B we	C	D	E	F	G
				=LinR			
1	0	124	Title...	Line...			
2	1	121	Reg...	m*x...			
3	4	103	m	-5.5...			
4	5	96	b	123....			
5	6	90	r²	.995...			

A1 0



Question

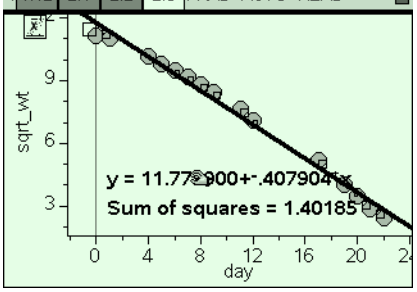
4. Can you find a better model for this data? Justify your result.

Answer

The quadratic hypothesis appears reasonable and worth testing.

	A day	B we...	C sq...	D	E	F
			= √ (we			
1	0	124	2*√ (...			
2	1	121	11			
3	4	103	√ (10...			
4	5	96	4*√ (...			
5	6	90	3*√ (...			

C sqrt_wt:=√weight



Question

5. How would describe the way that the weight of a bar of soap decreases over time with reference to the data provided.

Answer

The linear model has a very high r^2 value,