Kayak Mathematics

Elana Reiser
St. Joseph's College

One way to motivate students is to relate mathematical topics to student interests and the real world. One such example can be found on the television show *Shark Tank*. On *Shark Tank*, there are six business entrepreneurs (the Sharks) looking for companies to invest in to help them grow. In each episode, a series of companies presents their idea to the Sharks in the hopes of gaining investment income and guidance in return for a percent of the company's future profits. In one episode (Carter, Fuchs, & Spirko, 2014), the first company to present was Oru Kayak. They build foldable kayaks.

Objectives

The activity described in this article is well-suited for an algebra class or a liberal arts mathematics course for nonmajors. Topics covered include setting up and solving word problems, linear and exponential regression, linear programming, and algebra. It is possible to pick and choose different components of this activity to match it to a specific course. The author has used this activity in a freshman seminar class. Students liked this activity because they were familiar with the television show and enjoyed that it was a real-world application. The main goal of this activity is to employ these various analytical tools to figure out if Oru Kayak gives a reasonable projection for their revenue within the next year, and, based on that projection, what a reasonable estimate for profit would be.

Assignment

1. How much revenue has the company made so far?

Oru Kayak sells kayaks for $1100. The Shark's questions reveal that the company had sold 1228 kayaks to that point, leading to $1.1 million in sales. To calculate total sales, have students multiply the cost by the number of units sold. This yields $\$1100 \times 1228 = \$1,350,800$. Students can consider why this calculation does not lead to the given $1.1 million figure. Perhaps they sold some of the kayaks at a discounted rate to help market their kayaks.

The kayaks cost $505 to build, but Oru Kayak hopes to decrease the cost to $350 in the next year. With these two different price points, students can begin to think about building a model that is more interesting and involves higher level mathematics than a single point model.

2. How many kayaks does Oru Kayak expect to sell in the next year?

Since each kayak sells for $1100, divide $4 million by $1100 to get projected sales of 3637 kayaks, when rounding up. Prompt students to discuss whether their projection is reasonable. The company started with a Kickstarter campaign over a period of 2 months (November and December 2012) and sold 473 kayaks. The *Shark Tank* episode was filmed in the fall of 2013. For the sake of calculations, assume that the month was October. At this point, 1228 kayaks had been sold. There is not enough data to do a full analysis, but a first simple approximation is to assume that the company had a linear growth rate. To get a line of best fit, use the known points in the form $(x, y) =$ (months since company started, number of kayaks sold). The first data point is $(2, 473)$ because the Kickstarter campaign launched the company, but had not sold any kayaks before that point. The other data point is $(11, 1228)$, since October 2013 is 11 months since the company's inception.

3. Use these two points to get a line of best fit.

Plugging both of these points into the general $y = mx + b$ formula yields $473 = 2m + b$ and $1228 = 11m + b$. Solving these simultaneous equations results in the equation $y = 83.9x + 305.2$ (see Figure 1).

4. Use the equation you got to estimate the number of kayaks sold a year from the airing of the Shark Tank episode.

To project the sales a year from the airing of the *Shark Tank* episode, add 12 months, giving $x = 23$. The linear equation predicts that 2235 kayaks were sold in the first 23 months. To get the total number sold just in the next year, subtract the

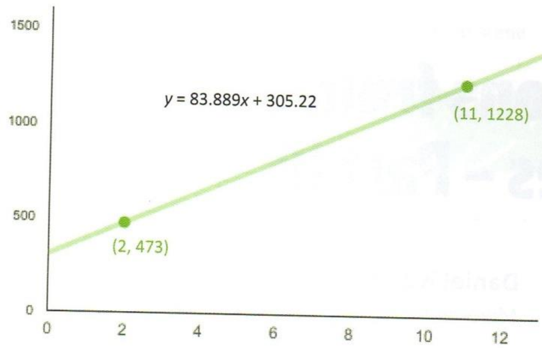

Figure 1. Linear regression.

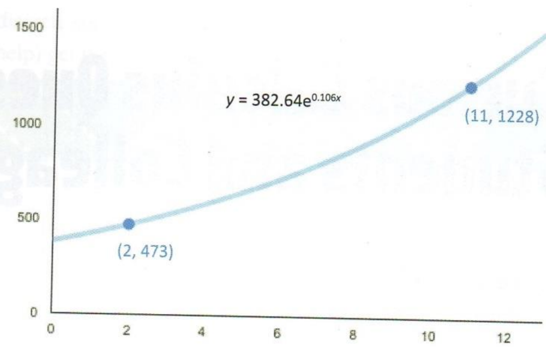

Figure 2. Exponential regression.

1228 already sold from the projected 2235, which gives 1007 new kayak sales. This is pretty far off from the projected 3637 kayaks. At this point, there is evidence that a linear model is not the best choice for this situation. Perhaps an exponential model is a better choice.

5. Using the $(2, 473)$ and $(11, 1228)$ data points, find an exponential model and calculate the number of kayaks sold in the next year.

Use a calculator or spreadsheet to get the exponential model $y = 382.64e^{0.106x}$ (see Figure 2). Plug in $x = 23$ and subtract the first 1228 kayaks to get the result that 3153 kayaks sold in the next year. This is much closer to the predicted 3637 kayaks.

6. Let $x =$ the number of units sold for \$505 and $y =$ the number of units sold for \$350. Write two equations with *x* and *y*, one for total units sold and one for total profit (P).

In the exponential model, $x + y = 3153.$ The profit will be the price the kayak sells for minus the cost of production times the number of kayaks sold at that production cost. This gives $(1100-505)x+(1100-350)y = P,$ which simplifies to $595x+750y = P.$

7. Maximize the profit equation you got in question 6 based on the constraints

$$\begin{cases} x \geq 0, \\ y \geq 0, \\ x + y = 3153. \end{cases}$$

Explain why your solution is not realistic based on our knowledge of the company.

First, plot the three constraints and find the feasibility region. Use the graph (see Figure 3), to identify the corner points: the two intercepts and the origin.

Plug each of these points into the profit equation to determine the maximum profit \$2,364,750 at $(0, 3153)$. At this point, the *x* value is zero, meaning no kayaks are made at the \$505 price point. This will not be the case because even though Oru Kayak is looking to bring the price down, they cannot do so right away. Since this result is not reasonable, students need to continue the exploration.

Continued on page 53.

Elana Reiser has been teaching math for 13 years. She lives on Long Island with her husband and 5-year-old daughter. She is the author of the books, *Teaching Mathematics Using Popular Culture* (www.popculturemath.com) and *3D Printing in the K–12 Mathematics Classroom.* Many of her 3D printed lessons can be found on http://thingiverse.com/education.