Introduction

In the last few years, Rose-Hulman has installed several water filling stations that attach to water fountains in order to encourage the use of permanent water bottles or the recycling of old plastic bottles for additional uses. Moreover, there is a particular time needed to completely fill a water bottle. During finals week, there is a substantial time crunch for many Rose-Hulman students and optimizing their time is crucial. In this investigation, we are interested in determining if there is a statistical difference between the average filling time to fill a 16.9 fluid ounce water bottle by using the Lakeside one or BSB one water filling stations. With this information, one can better understand the average time it takes to fill a water bottle and determine the location at which a student could optimize their time if there happens to be a statistical difference between the filling times. In this study, we expect there to be a difference in average filling times because of variability in manufacturing and calibration, but it might not be practically significant for most individuals.

In short, we summarize our question of interest:

To determine if there is a statistical difference between the average filling times of a 16.9 fl oz plastic bottle by using either the Lakeside one or BSB one water filling stations

Methodology

In our investigation, we utilized a systematic sample that is representative of water station behavior. We measured the time it took to fill a 16.9 fl oz water bottle completely. Specifically, one group member performed the data collection for each water filling station and used the same water bottle to keep more variables constant. As soon as water began flowing, time was started. As soon as the bottle overflowed with water, time was stopped. In the interest of time, we did not randomize the order of switching back and forth between fountains. Instead, 30 consecutive samples were taken from each water fountain.

In order to analyze the data, we utilized an independent two sample z test using Minitab statistical software. Our data are not paired because we are comparing two different filling stations. The following assumptions were required: large sample size (greater than or equal to 30 for each location) and independent and identically distributed (IID) variables. According to Figure 1, the time series plot demonstrates that both sets of data are IID because there is no distinct trending behavior. Additionally, we have 30 samples for each location, and we can therefore use a z-score from the standard normal distribution by the central limit theorem. To graphically compare the filling times, a box-plot with an average difference line was utilized; this plot demonstrates the summarized raw data (average, percentiles) and communicates the difference between the averages. (See Figure 2)

To address our question of interest, we constructed the following hypothesis test:

$$H_o: \mu_{BSB} = \mu_{Lake} \ or \ \mu_{BSB} - \mu_{Lake} = 0$$

$$H_1: \mu_{BSB} \neq \mu_{Lake} \ or \ \mu_{BSB} - \mu_{Lake} \neq 0$$

Where:

μ is the average filling time for a 16.9 fl oz bottle.
H_0 and H_1 are the null and alternative hypotheses respectively.

In other words, we collected water filling times to determine if there is evidence for a statistical difference between the average filling times when using either the BSB or Lakeside water filling stations.

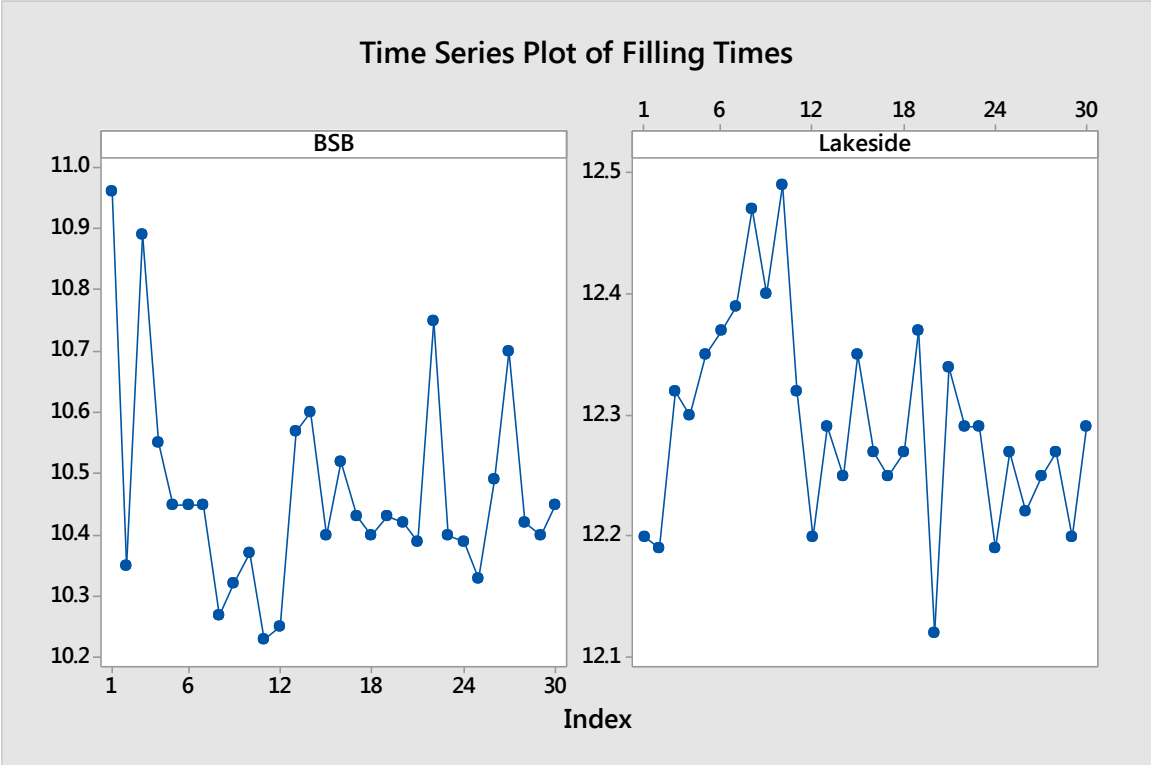

Figure 1. Assessing the IID assumption for both water filler stations. According to both plots, there seems to be no general trends.

Conclusions

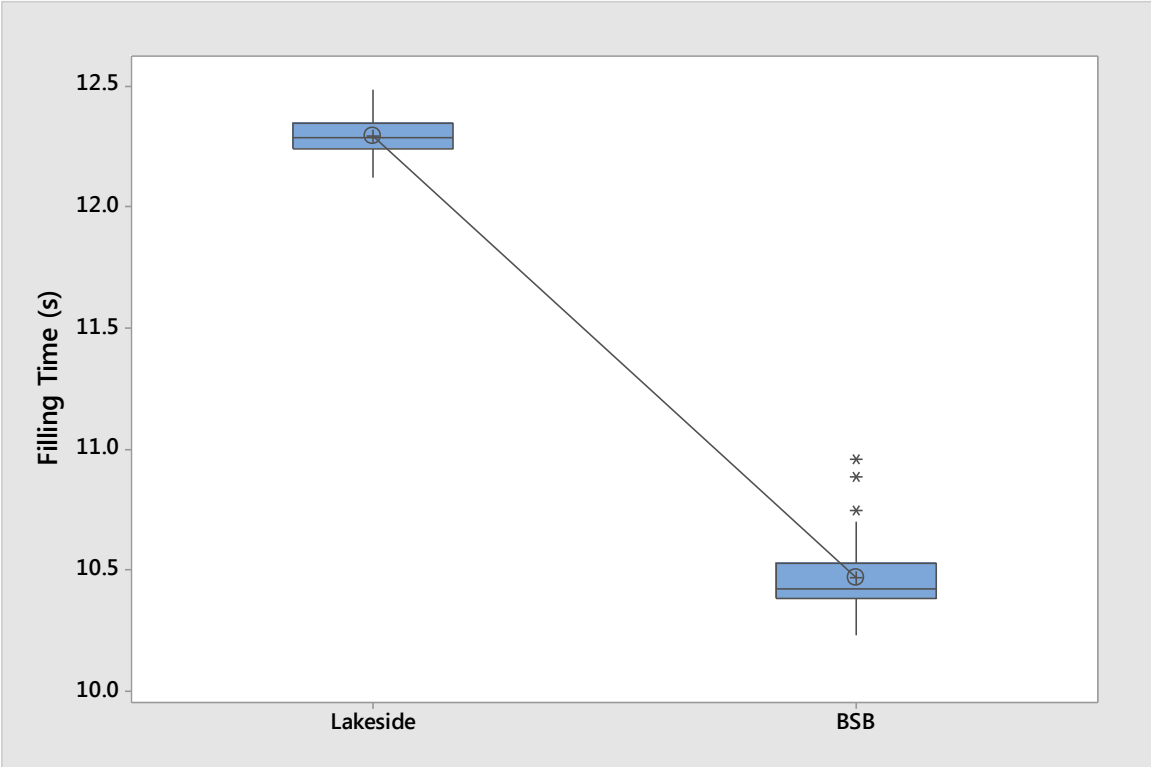

Figure 2. Graphical representation of summarized data with a clear difference between the average filling times.

Table 1. Statistical summary of our filling times with confidence and p-values

Location	Average (s)	Standard deviation (s)	Estimated difference with p-value, CI
Lakeside	12.293	0.0837	1.8250 s p-value: 0.000 (1.7552 s, 1.8948 s)
BSB	10.468	0.1700	

According to Figure 2 and Table 1, there is evidence for a statistical difference between the average filling times of the BSB and Lakeside water filler stations. This is justified by the p-value and confidence interval presented in Table 1. Because the confidence interval did not contain zero, there is evidence for a non-zero difference between the average filling times.

With this information, we can conclude that there is statistical difference between filling times. Because we only have two samples, we can also logically conclude that it takes longer to fill with the Lakeside 1 station. (Ideally, we should re-define our hypothesis to rigorously support this conclusion). With this information, one might utilize the BSB water filter station to more quickly fill their water bottle on average.