Water Consumption of Students at Dickinson College

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Introduction

Water usage is an important metric that is measured to obtain knowledge on resource sustainability in society. Dickinson has already made efforts in reducing water consumption among academic and residential buildings. Examples include:

- Water bottle filling stations
- Alliance for Aquatic Resource Monitoring (ALLARM)

Objectives

- To obtain a general idea of the difference in water consumption between first-years and upperclassmen.
- Determine if there is any evidence that first-years consume more water (ccf/person) than upperclassmen.

Data

Our original data consists of water usage in centum cubic feet (CCF) for every building on campus. The data was collected monthly starting in June 2011 until June 2021.

- Spring semester: Jan. through May
- Fall semester: Sept. through Dec.
- Upper-class: Sophomores, Juniors, Seniors
- Deleted data for the Spring and Fall semesters of 2020 → not representative of population due to Covid-19
- Data converted to water consumption per person, filtered by class year buildings, and averaged.

Methods

Here, we are testing the differences between two means of independent samples (Unequal Variances)

*No occupancy data for Fall 2015 and Spring 2016, so these semesters are not included

Facility	Fall 2013	Spring 2014	Fall 2014	Spring 2015	Fall 2016	Spring 2017	Fall 2017	Spring 2018	Fall 2018	Spring 2019	MEAN
First-Years	4.589	6.225	4.475	4.407	4.427	4.115	4.329	4.988	4.375	4.499	4.643
UpperClassmen	4.622	4.738	3.854	4.262	4.135	4.310	3.519	4.429	3.381	4.168	4.142

Figure 1: Excel screenshot of water usage per person, per semester, grouped by first-year and upperclassmen residential buildings

Let μ_1 = mean water consumption per Person (ccf/person) for first-years from 10 semesters between Fall 2013 and Spring 2019

Let μ_2 = mean water consumption per person (ccf/person) for upperclassmen from 10 semesters between Fall 2013 and Spring 2019

H_0: $\mu_1 - \mu_2 = 0$
H_1: $\mu_1 - \mu_2 > 0$

After calculating the test statistic and the degrees of freedom, the results are:
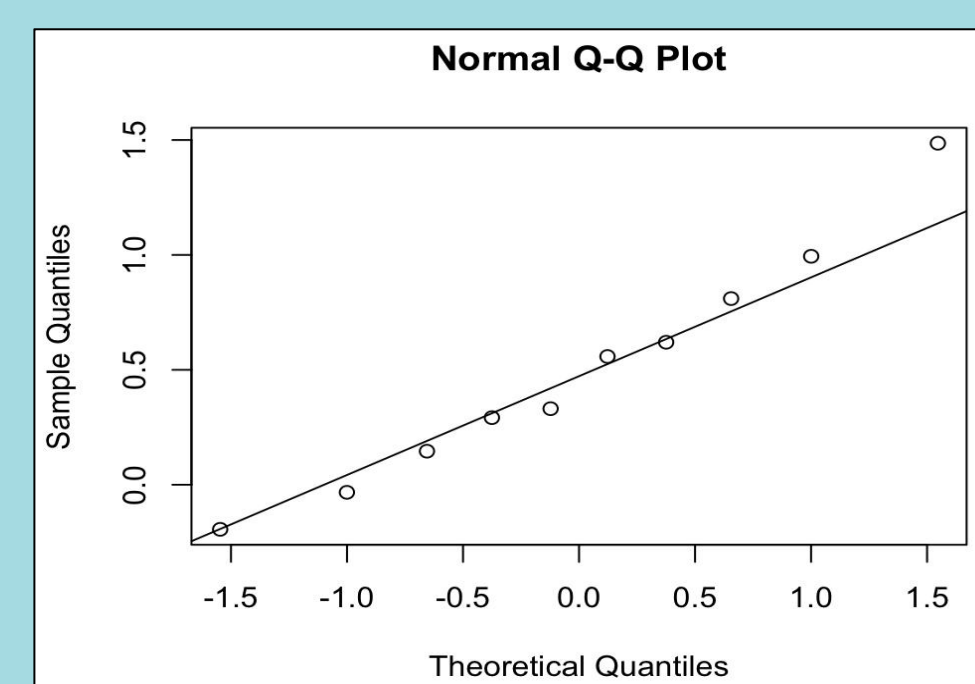
t' = 2.13, df = 16
Therefore, **p-value = 0.024521**

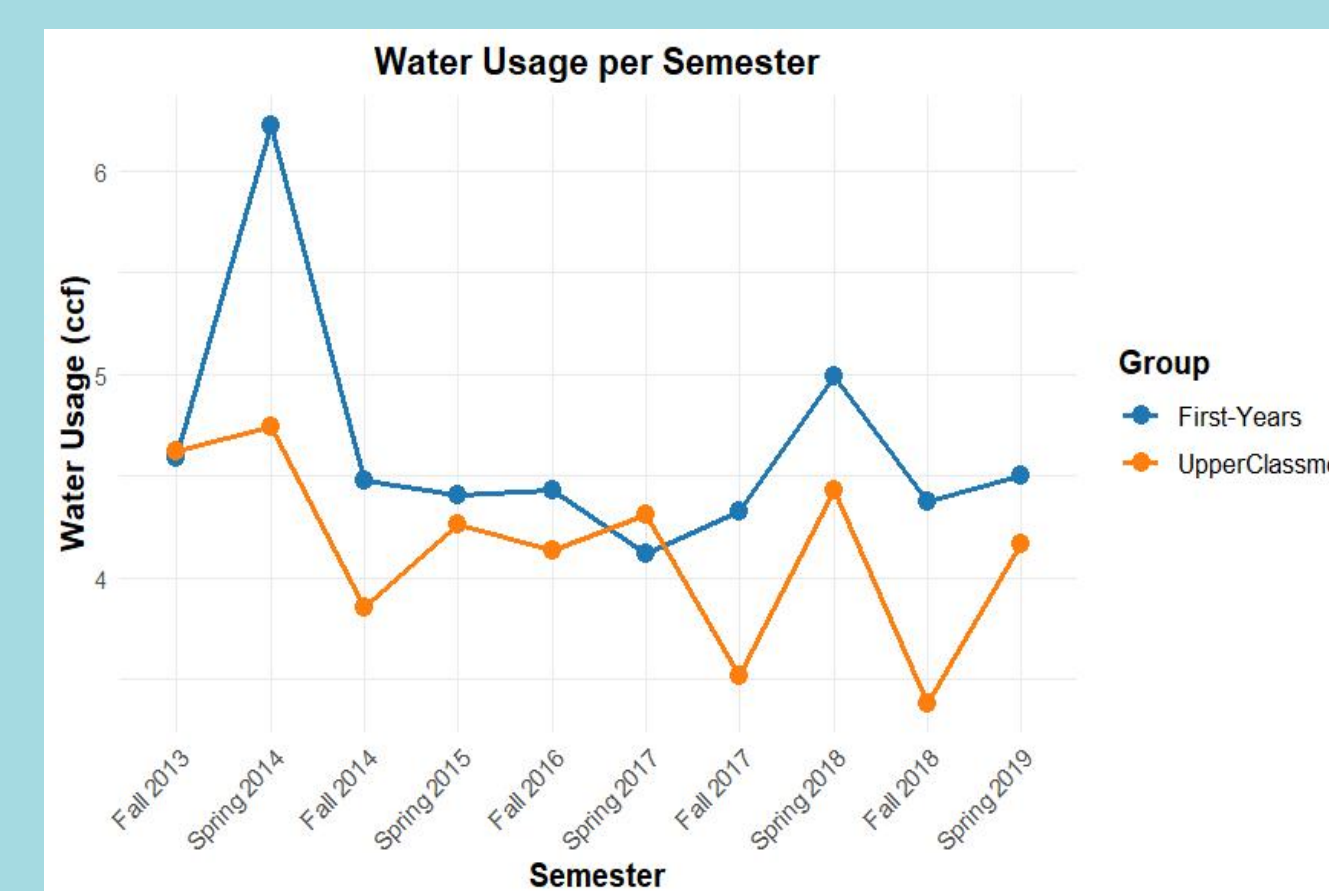Figure 2: Line graph of water usage per semester for both groups
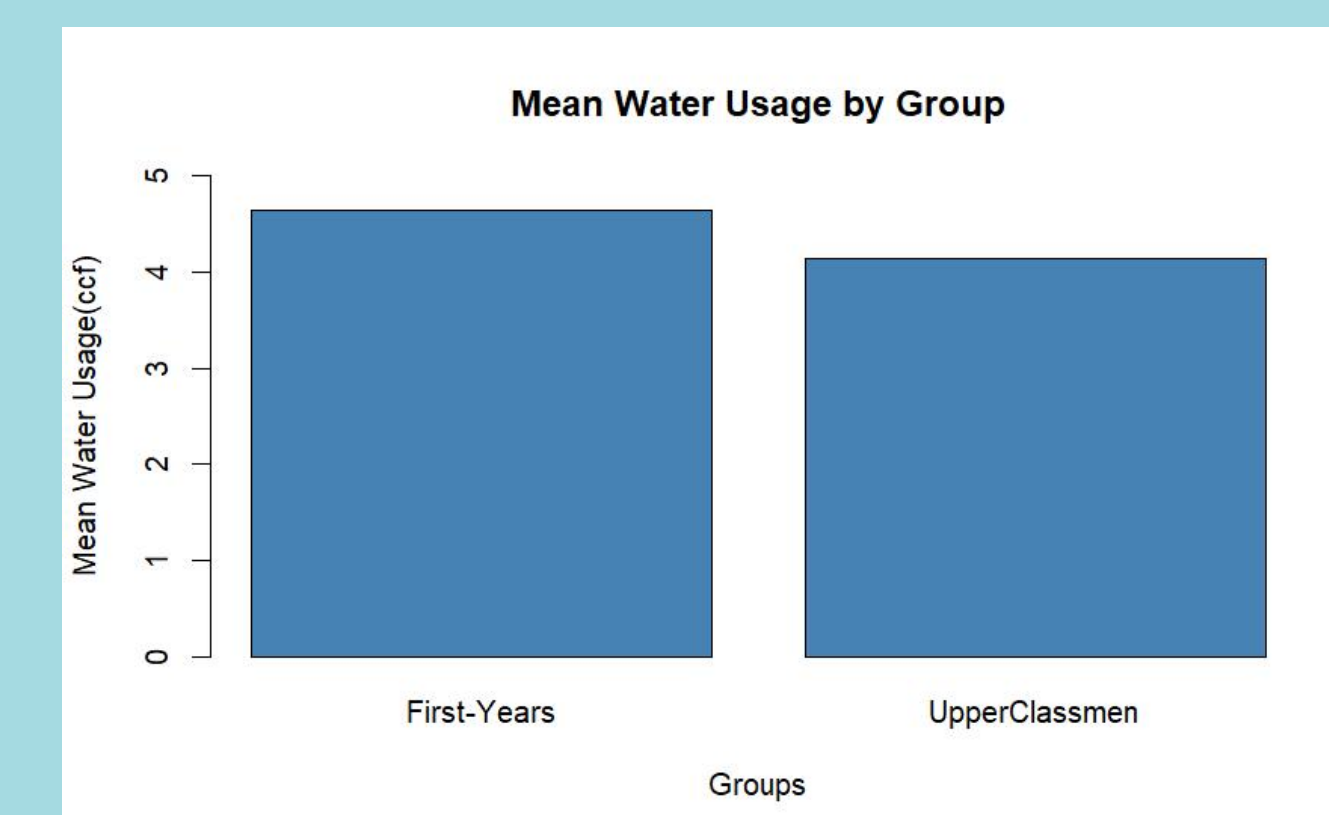
Figure 3: Bar graph of mean water usage between groups

Figure 4: Normal Q-Q Plot; a normal model is reasonable because points follow a relatively positive, linear pattern

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Shapiro-Wilk Test for Mean Differences:

      Shapiro-Wilk normality test

data:  mean_diff
W = 0.97265, p-value = 0.9142
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Figure 5: R output of SW test for normality, p-value indicates a normal distribution is appropriate for this data

Conclusions

We reject H_0 at $\alpha = 0.05$ level since p-value = 0.024521 < 0.05. There is moderate evidence that first-year students consume more water than upperclassmen.

- We believe that this makes logical sense because upperclassmen have more exposure to Dickinson's sustainability efforts and are more inclined to join the sustainable community (and reduce water consumption).
- Are there ways to reduce first year water consumption? Install more automatic sensor faucets?
- Do automatic sensor faucets reduce water consumption?

References

We received water usage data from the Center for Sustainability Education at Dickinson College. (4/6/2023)

Occupancy data was received from Residence Life and Housing at Dickinson College. (4/25/2023)

- First-Year Buildings: Adams, Armstrong, Atwater, Longsdorf, Drayer, Baird McClintock, Spradley-Young, Conway
- Upperclassmen Buildings: Goodyear, Malcolm, Morgan, McKenney, Kisner-Woodward, Buchanan