StudentPerformance HypTesting Project

February 7, 2022

[28]:
```
import pandas as pd
import matplotlib.pyplot as plt
from scipy.stats import ttest_ind, chi2_contingency, f_oneway
import numpy as np
import nbconvert
import seaborn as sns
from statsmodels.stats.multicomp import pairwise_tukeyhsd
```

[29]:
```
# data source: https://www.kaggle.com/spscientist/students-performance-in-exams␣
 ↪ It should be noted that this is fictional data.
student_df = pd.read_csv('StudentsPerformance.csv')
print("First 5 rows of data: ")
print(student_df.head())
print("Column info: ")
print(student_df.info())
print("Stats on Numerical Columns: ")
print(student_df.describe())
```

```
First 5 rows of data:
   gender race/ethnicity parental level of education         lunch  \
0  female        group B           bachelor's degree      standard
1  female        group C                some college      standard
2  female        group B            master's degree      standard
3    male        group A          associate's degree  free/reduced
4    male        group C                some college      standard

  test preparation course  math score  reading score  writing score
0                    none          72             72             74
1               completed          69             90             88
2                    none          90             95             93
3                    none          47             57             44
4                    none          76             78             75
Column info:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 8 columns):
 #   Column                       Non-Null Count  Dtype
---  ------                       --------------  -----
```

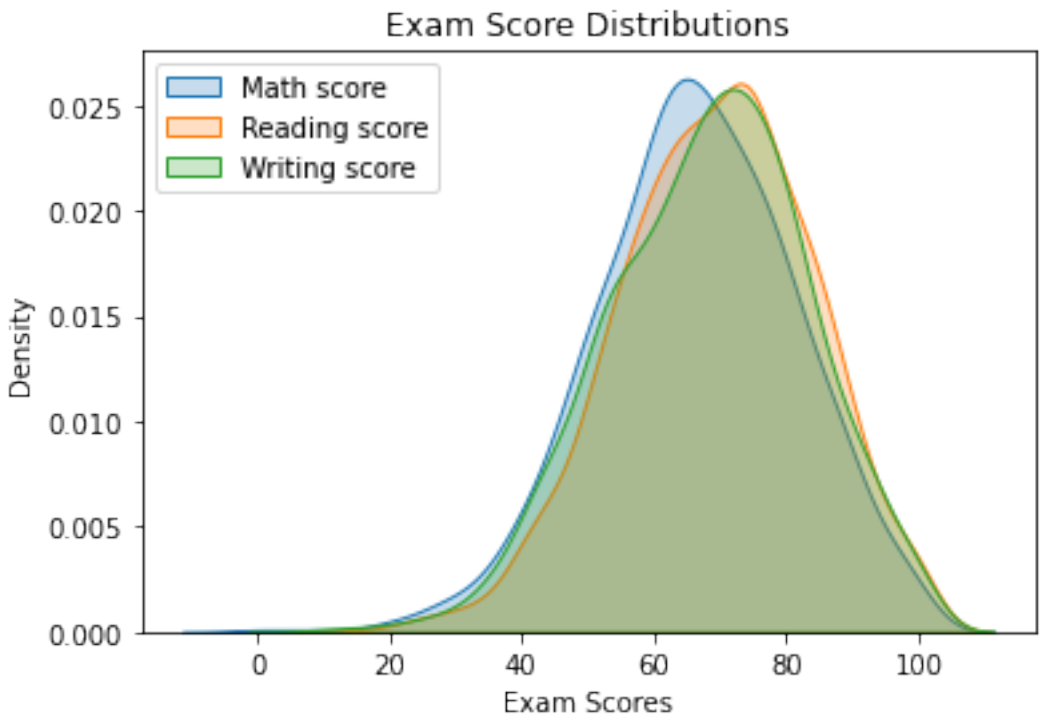
```
 0   gender                       1000 non-null   object
 1   race/ethnicity               1000 non-null   object
 2   parental level of education  1000 non-null   object
 3   lunch                        1000 non-null   object
 4   test preparation course      1000 non-null   object
 5   math score                   1000 non-null   int64
 6   reading score                1000 non-null   int64
 7   writing score                1000 non-null   int64
dtypes: int64(3), object(5)
memory usage: 62.6+ KB
None
Stats on Numerical Columns:
       math score  reading score  writing score
count  1000.00000    1000.000000    1000.000000
mean     66.08900      69.169000      68.054000
std      15.16308      14.600192      15.195657
min       0.00000      17.000000      10.000000
25%      57.00000      59.000000      57.750000
50%      66.00000      70.000000      69.000000
75%      77.00000      79.000000      79.000000
max     100.00000     100.000000     100.000000
```

[30]:
```
#Data Cleaning

#rename columns to variable-friendly names
student_df.columns = ['gender', 'ethnicity', 'parent_ed', 'lunch', 'test_prep',␣
 ↪'math_score', 'reading_score', 'writing_score']

#replace free/reduced from lunch column to variable_friendly name
student_df.lunch = student_df.lunch.replace('free/reduced', 'free_or_reduced')
print(student_df.lunch.value_counts())
print()

#remove apostrophe from degree titles for easier string usage
student_df.parent_ed = student_df.parent_ed.replace("associate's degree",␣
 ↪'associate degree')
student_df.parent_ed = student_df.parent_ed.replace("bachelor's degree",␣
 ↪'bachelor degree')
student_df.parent_ed = student_df.parent_ed.replace("master's degree", 'masters␣
 ↪degree')

#parental level of education should be an ordinal categorical variable rather␣
 ↪than nominal
print(student_df.parent_ed.value_counts()), print()
student_df.parent_ed = pd.Categorical(student_df.parent_ed, ['some high␣
 ↪school', 'high school', 'some college', 'associate degree', 'bachelor␣
 ↪degree', 'masters degree'], ordered = True)
```

```
print(student_df.parent_ed.unique())
```

```
standard           645
free_or_reduced    355
Name: lunch, dtype: int64

some college        226
associate degree    222
high school         196
some high school    179
bachelor degree     118
masters degree       59
Name: parent_ed, dtype: int64

['bachelor degree', 'some college', 'masters degree', 'associate degree', 'high
school', 'some high school']
Categories (6, object): ['some high school' < 'high school' < 'some college' <
'associate degree' < 'bachelor degree' < 'masters degree']
```

[31]:
```
sns.kdeplot(student_df.math_score, shade=True)
sns.kdeplot(student_df.reading_score, shade=True)
sns.kdeplot(student_df.writing_score, shade=True)
plt.legend(["Math score", "Reading score", "Writing score"], loc = 2)
plt.xlabel("Exam Scores")
plt.title("Exam Score Distributions")
plt.savefig('exam_distr.png')
plt.show()
plt.clf()
```

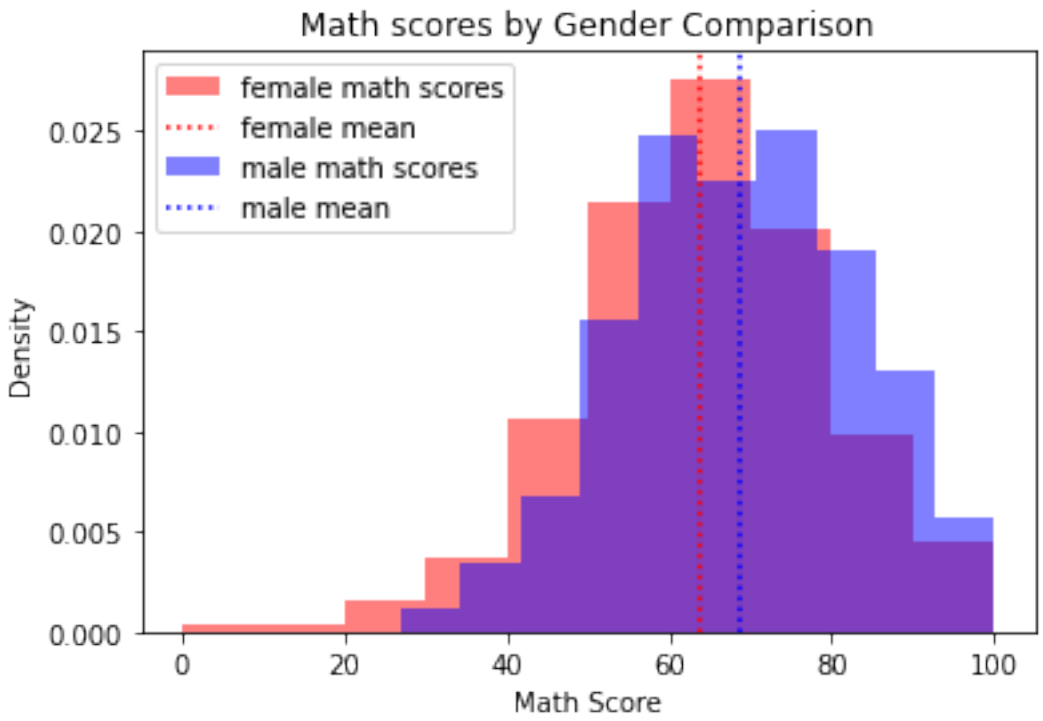



```
<Figure size 432x288 with 0 Axes>
```

[32]:
```
#Hypothesis 1: relation between gender and math score
#Null Hyp: There is no association between a student's gender and their math␣
 ↪score.
#Alt Hyp: There is a significant difference (5% significance threshhold)␣
 ↪between the math scores of males vs females

#print(student_df.gender.value_counts())

female_math_scores = student_df.math_score[student_df.gender == 'female']
male_math_scores = student_df.math_score[student_df.gender == 'male']

female_math_mean = np.mean(female_math_scores)
male_math_mean =  np.mean(male_math_scores)
print("Mean math score of female students: " + str(female_math_mean))
print("Mean math score of male students: " + str(male_math_mean))
print("Mean difference: " + str(female_math_mean - male_math_mean))

plt.hist(female_math_scores, color = 'red', label = "female math scores",␣
 ↪density = True, alpha = 0.5)
plt.axvline(female_math_mean, color = 'r', linestyle = 'dotted', label =␣
 ↪"female mean")
```

```
plt.hist(male_math_scores, color = 'blue', label = "male math scores", density␣
 ↪= True, alpha = 0.5)
plt.axvline(male_math_mean, color = 'b', linestyle = 'dotted', label = "male␣
 ↪mean")
plt.legend()
plt.xlabel("Math Score")
plt.ylabel("Density")
plt.title("Math scores by Gender Comparison")
plt.savefig('gender_math_hist.png')
plt.show()
plt.clf()

#Two-sample T-Test
tstat, pval = ttest_ind(female_math_scores, male_math_scores)
print("P-Value: " + str(pval))
if pval < 0.05:
    print("There is a statistically significant difference between female and␣
 ↪male math scores.")
    if female_math_mean > male_math_mean:
        print("Female students averaged higher with statistical significance.")
    else:
        print("Male students averaged higher with statistical significance.")
else:
    print("There is NOT a statistically significant difference between female␣
 ↪and male math scores.")
print()
```

```
Mean math score of female students: 63.633204633204635
Mean math score of male students: 68.72821576763485
Mean difference: -5.095011134430216
```




```
P-Value: 9.120185549328822e-08
There is a statistically significant difference between female and male math
scores.
Male students averaged higher with statistical significance.

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```
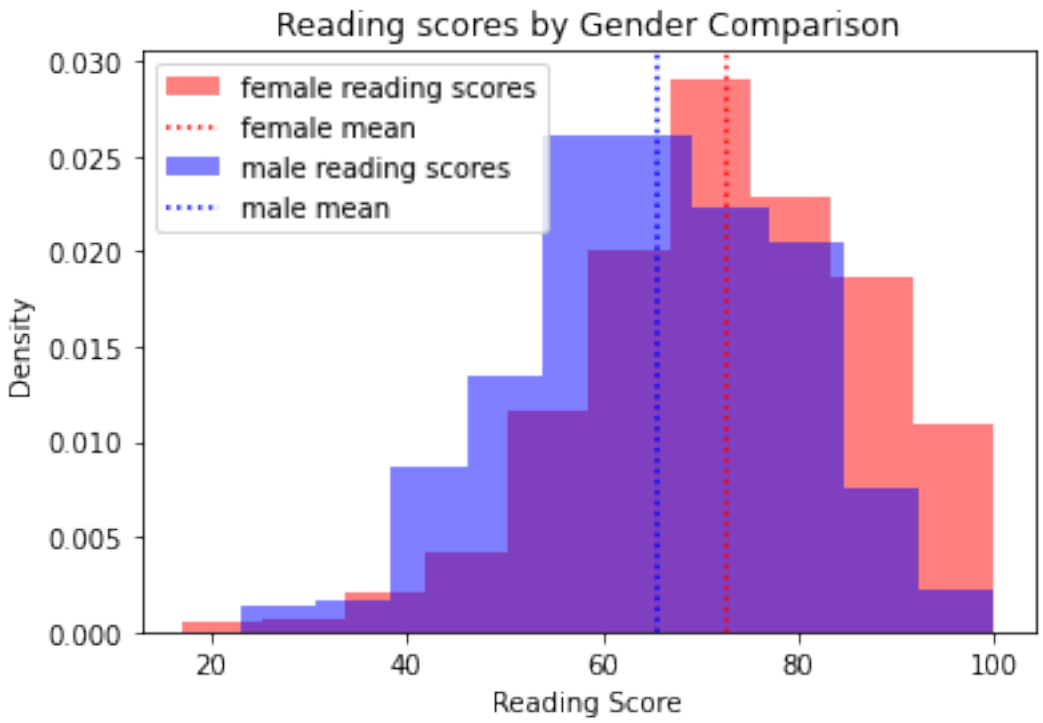

[ ]:

[33]:
```
#Hypothesis 2: relation between gender and reading score
#Null Hyp: There is no association between a student's gender and their reading␣
 ↪score.
#Alt Hyp: There is a significant difference (5% significance threshhold)␣
 ↪between the reading scores of males vs females

female_reading_scores = student_df.reading_score[student_df.gender == 'female']
male_reading_scores = student_df.reading_score[student_df.gender == 'male']

female_reading_mean = np.mean(female_reading_scores)
male_reading_mean =  np.mean(male_reading_scores)
print("Mean reading score of female students: " + str(female_reading_mean))
print("Mean reading score of male students: " + str(male_reading_mean))
print("Mean difference: " + str(female_reading_mean - male_reading_mean))
```

```
plt.hist(female_reading_scores, color = 'red', label = "female reading scores",␣
 ↪density = True, alpha = 0.5)
plt.axvline(female_reading_mean, color = 'r', linestyle = 'dotted', label =␣
 ↪"female mean")
plt.hist(male_reading_scores, color = 'blue', label = "male reading scores",␣
 ↪density = True, alpha = 0.5)
plt.axvline(male_reading_mean, color = 'b', linestyle = 'dotted', label = "male␣
 ↪mean")
plt.legend()
plt.xlabel("Reading Score")
plt.ylabel("Density")
plt.title("Reading scores by Gender Comparison")
plt.savefig('gender_reading_hist.png')
plt.show()
plt.clf()

#Two-sample T-Test
tstat, pval = ttest_ind(female_reading_scores, male_reading_scores)
print("P-Value: " + str(pval))
if pval < 0.05:
    print("There is a statistically significant difference between female and␣
 ↪male reading scores.")
    if female_reading_mean > male_reading_mean:
        print("Female students averaged higher with statistical significance.")
    else:
        print("Male students averaged higher with statistical significance.")
else:
    print("There is NOT a statistically significant difference between female␣
 ↪and male reading scores.")
print()
```

```
Mean reading score of female students: 72.60810810810811
Mean reading score of male students: 65.47302904564316
Mean difference: 7.135079062464953
```




```
P-Value: 4.680538743933289e-15
There is a statistically significant difference between female and male reading
scores.
Female students averaged higher with statistical significance.


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```
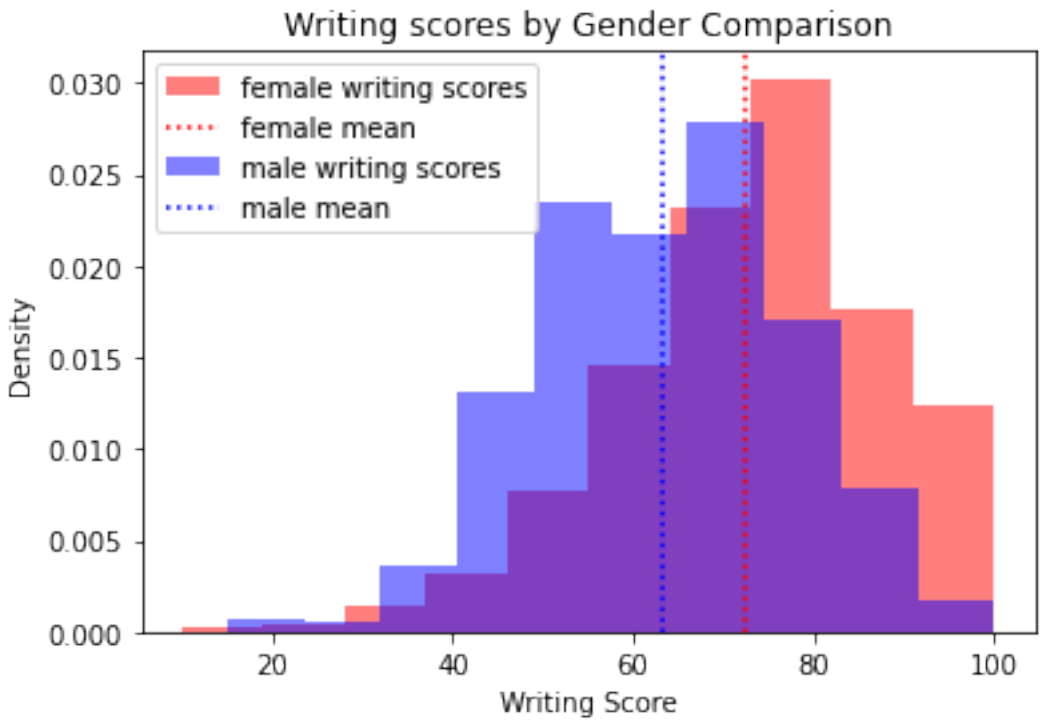

[34]:
```
#Hypothesis 3: relation between gender and writing score
#Null Hyp: There is no association between a student's gender and their writing␣
 ↪score.
#Alt Hyp: There is a significant difference (5% significance threshhold)␣
 ↪between the writing scores of males vs females

female_writing_scores = student_df.writing_score[student_df.gender == 'female']
male_writing_scores = student_df.writing_score[student_df.gender == 'male']

female_writing_mean = np.mean(female_writing_scores)
male_writing_mean =  np.mean(male_writing_scores)
print("Mean writing score of female students: " + str(female_writing_mean))
print("Mean writing score of male students: " + str(male_writing_mean))
print("Mean difference: " + str(female_writing_mean - male_writing_mean))
```

```
plt.hist(female_writing_scores, color = 'red', label = "female writing scores",␣
 ↪density = True, alpha = 0.5)
plt.axvline(female_writing_mean, color = 'r', linestyle = 'dotted', label =␣
 ↪"female mean")
plt.hist(male_writing_scores, color = 'blue', label = "male writing scores",␣
 ↪density = True, alpha = 0.5)
plt.axvline(male_writing_mean, color = 'b', linestyle = 'dotted', label = "male␣
 ↪mean")
plt.legend()
plt.xlabel("Writing Score")
plt.ylabel("Density")
plt.title("Writing scores by Gender Comparison")
plt.savefig('gender_writing_hist.png')
plt.show()
plt.clf()

#Two-sample T-Test
tstat, pval = ttest_ind(female_writing_scores, male_writing_scores)
print("P-Value: " + str(pval))
if pval < 0.05:
    print("There is a statistically significant difference between female and␣
 ↪male writing scores.")
    if female_writing_mean > male_writing_mean:
        print("Female students averaged higher with statistical significance.")
    else:
        print("Male students averaged higher with statistical significance.")
else:
    print("There is NOT a statistically significant difference between female␣
 ↪and male writing scores.")
print()
```

```
Mean writing score of female students: 72.46718146718146
Mean writing score of male students: 63.31120331950208
Mean difference: 9.155978147679384
```



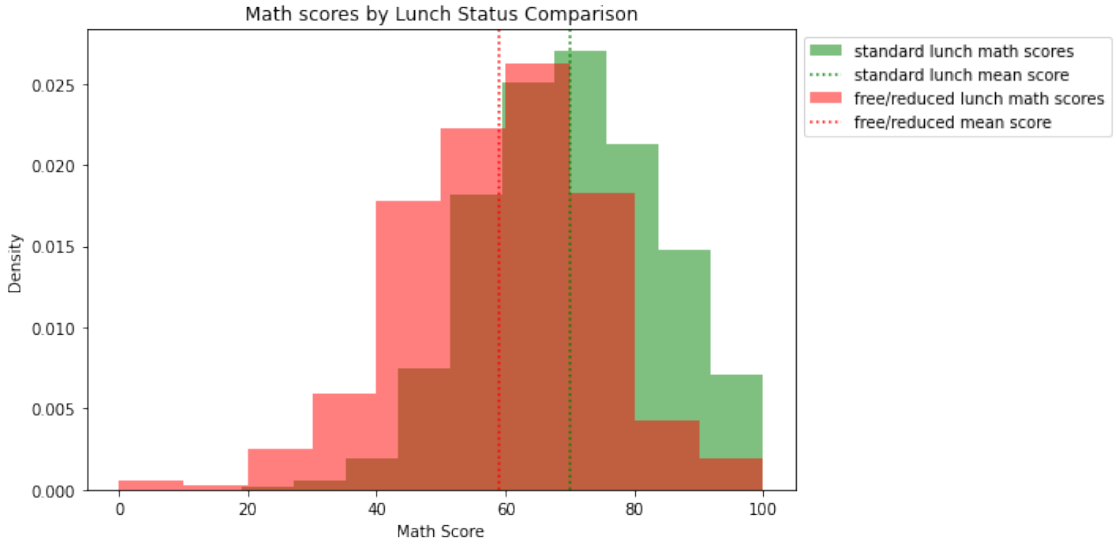

```
P-Value: 2.019877706867934e-22
There is a statistically significant difference between female and male writing
scores.
Female students averaged higher with statistical significance.
```

```
<Figure size 432x288 with 0 Axes>
```

[35]:
```
#Hypothesis 4: relation between lunch type and math score
#Null Hyp: There is no association between a student's lunch type and their␣
 ↪math score.
#Alt Hyp: There is a significant difference (5% significance threshhold)␣
 ↪between the math scores of free/reduced lunches vs standard lunches

standard_math_scores = student_df.math_score[student_df.lunch == 'standard']
free_or_reduced_math_scores = student_df.math_score[student_df.lunch ==␣
 ↪'free_or_reduced']

standard_math_mean = np.mean(standard_math_scores)
free_or_reduced_math_mean =  np.mean(free_or_reduced_math_scores)
print("Mean math score of standard lunch students: " + str(standard_math_mean))
print("Mean math score of free/reduced lunch students: " +␣
 ↪str(free_or_reduced_math_mean))
print("Mean difference: " + str(standard_math_mean - free_or_reduced_math_mean))
```

```
plt.figure(figsize = (10, 5))
plt.hist(standard_math_scores, color = 'green', label = "standard lunch math␣
 ↪scores", density = True, alpha = 0.5)
plt.axvline(standard_math_mean, color = 'g', linestyle = 'dotted', label =␣
 ↪"standard lunch mean score")
plt.hist(free_or_reduced_math_scores, color = 'red', label = "free/reduced␣
 ↪lunch math scores", density = True, alpha = 0.5)
plt.axvline(free_or_reduced_math_mean, color = 'r', linestyle = 'dotted', label␣
 ↪= "free/reduced mean score")
plt.legend(bbox_to_anchor=(1, 1))
plt.xlabel("Math Score")
plt.ylabel("Density")
plt.title("Math scores by Lunch Status Comparison")
plt.tight_layout()
plt.savefig('lunch_math_hist.png')
plt.show()
plt.clf()

#Two-sample T-Test
tstat, pval = ttest_ind(standard_math_scores, free_or_reduced_math_scores)
print("P-Value: " + str(pval))
if pval < 0.05:
    print("There is a statistically significant difference between standard and␣
 ↪free/reduced lunch math scores.")
    if standard_math_mean > free_or_reduced_math_mean:
        print("Standard lunch students averaged higher with statistical␣
 ↪significance.")
    else:
        print("Free/reduced lunch students averaged higher with statistical␣
 ↪significance.")
else:
    print("There is NOT a statistically significant difference between standard␣
 ↪and free/reduced lunch math scores.")
print()
```

```
Mean math score of standard lunch students: 70.03410852713178
Mean math score of free/reduced lunch students: 58.92112676056338
Mean difference: 11.112981766568396
```




```
P-Value: 2.4131955993137074e-30
There is a statistically significant difference between standard and
free/reduced lunch math scores.
Standard lunch students averaged higher with statistical significance.


<Figure size 432x288 with 0 Axes>
```

[36]:
```
#Hypothesis 5: relation between lunch type and reading score
#Null Hyp: There is no association between a student's lunch type and their␣
 ↪reading score.
#Alt Hyp: There is a significant difference (5% significance threshhold)␣
 ↪between the reading scores of free/reduced lunches vs standard lunches

standard_reading_scores = student_df.reading_score[student_df.lunch ==␣
 ↪'standard']
free_or_reduced_reading_scores = student_df.reading_score[student_df.lunch ==␣
 ↪'free_or_reduced']

standard_reading_mean = np.mean(standard_reading_scores)
free_or_reduced_reading_mean =  np.mean(free_or_reduced_reading_scores)
print("Mean reading score of standard lunch students: " +␣
 ↪str(standard_reading_mean))
print("Mean reading score of free/reduced lunch students: " +␣
 ↪str(free_or_reduced_reading_mean))
print("Mean difference: " + str(standard_reading_mean -␣
 ↪free_or_reduced_reading_mean))

plt.figure(figsize = (10, 5))
```

```
plt.hist(standard_reading_scores, color = 'green', label = "standard lunch␣
 ↪reading scores", density = True, alpha = 0.5)
plt.axvline(standard_reading_mean, color = 'g', linestyle = 'dotted', label =␣
 ↪"standard lunch mean score")
plt.hist(free_or_reduced_reading_scores, color = 'red', label = "free/reduced␣
 ↪lunch reading scores", density = True, alpha = 0.5)
plt.axvline(free_or_reduced_reading_mean, color = 'r', linestyle = 'dotted',␣
 ↪label = "free/reduced mean score")
plt.legend(bbox_to_anchor=(1, 1))
plt.xlabel("Reading Score")
plt.ylabel("Density")
plt.title("Reading scores by Lunch Status Comparison")
plt.tight_layout()
plt.savefig('lunch_reading_hist.png')
plt.show()
plt.clf()

#Two-sample T-Test
tstat, pval = ttest_ind(standard_reading_scores, free_or_reduced_reading_scores)
print("P-Value: " + str(pval))
if pval < 0.05:
    print("There is a statistically significant difference between standard and␣
 ↪free/reduced lunch reading scores.")
    if standard_reading_mean > free_or_reduced_reading_mean:
        print("Standard lunch students averaged higher with statistical␣
 ↪significance.")
    else:
        print("Free/reduced lunch students averaged higher with statistical␣
 ↪significance.")
else:
    print("There is NOT a statistically significant difference between standard␣
 ↪and free/reduced lunch reading scores.")
print()
```

```
Mean reading score of standard lunch students: 71.65426356589147
Mean reading score of free/reduced lunch students: 64.65352112676057
Mean difference: 7.000742439130903
```


```
P-Value: 2.0027966545279011e-13
There is a statistically significant difference between standard and
free/reduced lunch reading scores.
Standard lunch students averaged higher with statistical significance.


<Figure size 432x288 with 0 Axes>
```

[37]:
```
#Hypothesis 6: relation between lunch type and writing score
#Null Hyp: There is no association between a student's lunch type and their␣
 ↪writing score.
#Alt Hyp: There is a significant difference (5% significance threshhold)␣
 ↪between the writing scores of free/reduced lunches vs standard lunches

standard_writing_scores = student_df.writing_score[student_df.lunch ==␣
 ↪'standard']
free_or_reduced_writing_scores = student_df.writing_score[student_df.lunch ==␣
 ↪'free_or_reduced']

standard_writing_mean = np.mean(standard_writing_scores)
free_or_reduced_writing_mean =  np.mean(free_or_reduced_writing_scores)
print("Mean writing score of standard lunch students: " +␣
 ↪str(standard_writing_mean))
print("Mean writing score of free/reduced lunch students: " +␣
 ↪str(free_or_reduced_writing_mean))
print("Mean difference: " + str(standard_writing_mean -␣
 ↪free_or_reduced_writing_mean))

plt.figure(figsize = (9, 5))
```

```
plt.hist(standard_writing_scores, color = 'green', label = "standard lunch␣
 ↪writing scores", density = True, alpha = 0.5)
plt.axvline(standard_writing_mean, color = 'g', linestyle = 'dotted', label =␣
 ↪"standard lunch mean score")
plt.hist(free_or_reduced_writing_scores, color = 'red', label = "free/reduced␣
 ↪lunch writing scores", density = True, alpha = 0.5)
plt.axvline(free_or_reduced_writing_mean, color = 'r', linestyle = 'dotted',␣
 ↪label = "free/reduced mean score")
plt.legend(bbox_to_anchor=(1, 1))
plt.xlabel("Writing Score")
plt.ylabel("Density")
plt.title("Writing scores by Lunch Status Comparison")
plt.tight_layout()
plt.savefig('lunch_writing_hist.png')
plt.show()
plt.clf()

#Two-sample T-Test
tstat, pval = ttest_ind(standard_writing_scores, free_or_reduced_writing_scores)
print("P-Value: " + str(pval))
if pval < 0.05:
    print("There is a statistically significant difference between standard and␣
 ↪free/reduced lunch writing scores.")
    if standard_writing_mean > free_or_reduced_writing_mean:
        print("Standard lunch students averaged higher with statistical␣
 ↪significance.")
    else:
        print("Free/reduced lunch students averaged higher with statistical␣
 ↪significance.")
else:
    print("There is NOT a statistically significant difference between standard␣
 ↪and free/reduced lunch writing scores.")
print()
```

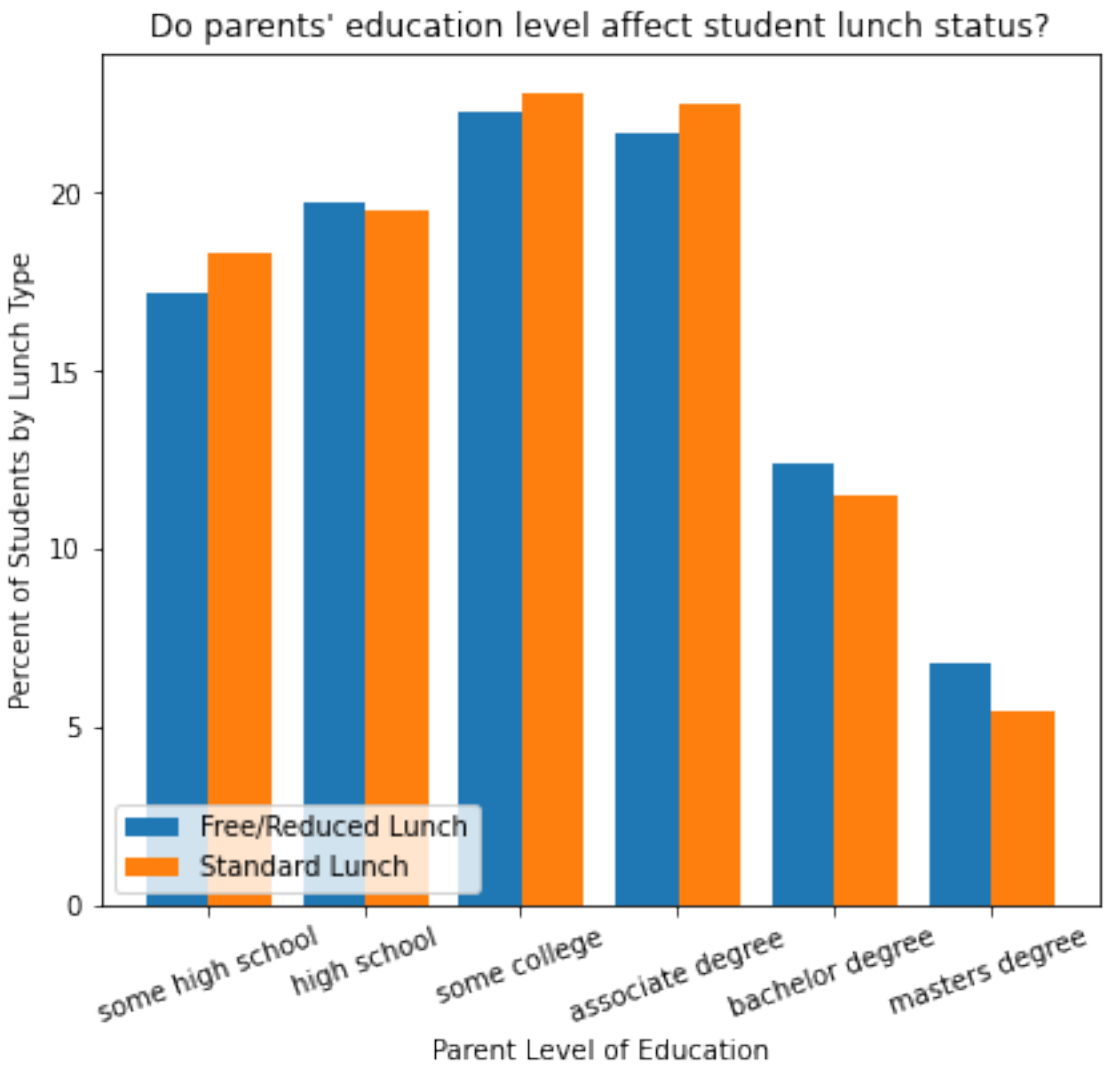
```
Mean writing score of standard lunch students: 70.8232558139535
Mean writing score of free/reduced lunch students: 63.02253521126761
Mean difference: 7.800720602685885
```


```
P-Value: 3.1861895831664765e-15
There is a statistically significant difference between standard and
free/reduced lunch writing scores.
Standard lunch students averaged higher with statistical significance.


<Figure size 432x288 with 0 Axes>
```

[38]:
```
#Hypothesis 7: relation between parental level of education and lunch
#Null Hyp: The education level of a student's parents has no impact on whether␣
 ↪they receive standard or free/reduced lunch
#Alt Hyp: There is a significant difference (5% significance threshhold)␣
 ↪between the the type of lunch service a student received based on their␣
 ↪parent's education level

#print(student_df.parent_ed.value_counts())
#print(student_df.lunch.value_counts())
#print(student_df.parent_ed.unique())

lunch_counts_by_parent_ed = student_df.groupby(['parent_ed', 'lunch']).gender.
 ↪count().reset_index()
lunch_counts_by_parent_ed.rename(columns = {'gender': 'count'}, inplace = True)
#print(lunch_counts_by_parent_ed)

#need [list of standard lunch counts, ordered by parent_ed], [list of␣
 ↪free_or_reduced lunch counts, ordered by parent_ed]
#pivot table?
```

```
#then will need to iterate through each list to convert it to a percent of the␣
 ↪sum of that list
lunch_counts_by_parent_ed = lunch_counts_by_parent_ed.pivot(columns =␣
 ↪'parent_ed', index = 'lunch', values = 'count').reset_index()
#print(lunch_counts_by_parent_ed), print()

lunch_counts_by_parent_ed_lists = lunch_counts_by_parent_ed.values.tolist()
#print(lunch_counts_by_parent_ed_lists)

freeReduced_by_parentEd = lunch_counts_by_parent_ed_lists[0]
freeReduced_by_parentEd.pop(0)
freeReduced_by_parentEd_perc = [np.round(100*i/np.sum(freeReduced_by_parentEd),␣
 ↪decimals = 1) for i in freeReduced_by_parentEd]
standard_by_parentEd = lunch_counts_by_parent_ed_lists[1]
standard_by_parentEd.pop(0)
standard_by_parentEd_perc = [np.round(100*i/np.sum(standard_by_parentEd),␣
 ↪decimals = 1) for i in standard_by_parentEd]
#print(freeReduced_by_parentEd_perc, standard_by_parentEd_perc)


# free/reduced lunch x placement
n = 1  # This is our first dataset (out of 2)
t = 2 # Number of datasets
d = 6 # Number of sets of bars
w = 0.8 # Width of each bar
x_values1 = [t*element + w*n for element  in range(d)]

# standard lunch x placement
n = 2  # This is our second dataset (out of 2)
t = 2 # Number of datasets
d = 6 # Number of sets of bars
w = 0.8 # Width of each bar
x_values2 = [t*element + w*n for element  in range(d)]

labels = ['some high school', 'high school', 'some college', 'associate␣
 ↪degree', 'bachelor degree', 'masters degree']
plt.figure(figsize = (6, 5.8))
plt.bar(x_values1, freeReduced_by_parentEd_perc)
plt.bar(x_values2, standard_by_parentEd_perc)
ax = plt.subplot()
ax.set_xticks(2*np.arange(len(labels))+1.18, labels, rotation = 20)
plt.ylabel("Percent of Students by Lunch Type")
plt.xlabel("Parent Level of Education")
plt.legend(['Free/Reduced Lunch', 'Standard Lunch'], loc = 3)
plt.title("Do parents' education level affect student lunch status?")
plt.tight_layout()
plt.savefig('lunch_parentEd_bar.png')
```

```
plt.show()
plt.clf()


#chi-square test
Xtab = pd.crosstab(student_df.parent_ed, student_df.lunch)
#print(Xtab)
chi2, pval, dof, expected = chi2_contingency(Xtab)
#print(expected)
print("P-Value: " + str(pval))
if pval < 0.05:
    print("There is a statistically significant relationship between parental␣
 ↪education level and whether the student receives free/reduced lunch.")
else:
    print("There is NOT a statistically significant relationship between␣
 ↪parental education level and whether the student receives free/reduced lunch.
 ↪")
```

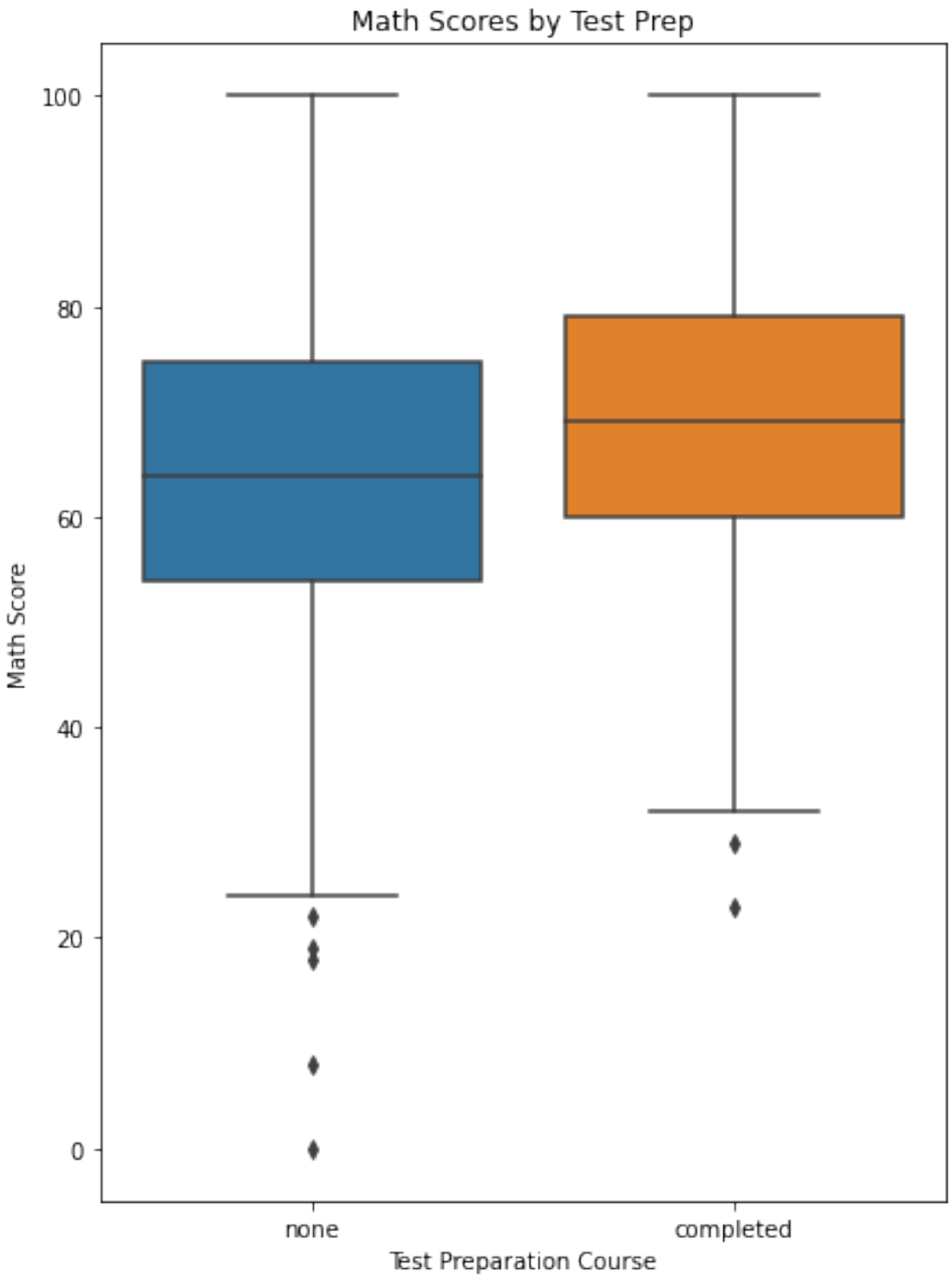



```
P-Value: 0.9531014927218223
There is NOT a statistically significant relationship between parental education
level and whether the student receives free/reduced lunch.

<Figure size 432x288 with 0 Axes>
```

[40]:
```
#Hypothesis 8: relation between test preparation course and math score
#Null Hyp: There is no association between whether a student took the test prep␣
 ↪course and their math score.
#Alt Hyp: There is a significant difference (5% significance threshhold)␣
 ↪between the math scores of students who took the test prep course vs those␣
 ↪who did not.
```

```
testprep_math_scores = student_df.math_score[student_df.test_prep ==␣
 ↪'completed']
#print(testprep_math_scores.describe())
noprep_math_scores = student_df.math_score[student_df.test_prep == 'none']
#print(noprep_math_scores.describe())

testprep_math_mean = np.mean(testprep_math_scores)
noprep_math_mean =  np.mean(noprep_math_scores)
print("Mean math score of students who completed the Test Prep Course: " +␣
 ↪str(testprep_math_mean))
print("Mean math score of students who did not complete the Test Prep Course: "␣
 ↪+ str(noprep_math_mean))
print("Mean difference: " + str(testprep_math_mean - noprep_math_mean))

#side by side box plots for scores based on test prep
plt.figure(figsize = (6,8))
sns.boxplot(data = student_df, x = 'test_prep', y = 'math_score')
plt.ylabel("Math Score")
plt.xlabel("Test Preparation Course")
plt.title("Math Scores by Test Prep")
plt.tight_layout()
plt.savefig('testprep_math.png')
plt.show()

#Two-sample T-Test
tstat, pval = ttest_ind(testprep_math_scores, noprep_math_scores)
print("P-Value: " + str(pval))
if pval < 0.05:
    print("There is a statistically significant difference between math scores␣
 ↪of students who completed the test prep course vs those who didn't.")
    if testprep_math_mean > noprep_math_mean:
        print("Students who completed the test prep course averaged higher with␣
 ↪statistical significance.")
    else:
        print("Students who did NOT complete the test prep course averaged␣
 ↪higher with statistical significance.")
else:
    print("There is NOT a statistically significant difference between math␣
 ↪scores of students who completed the test prep course vs those who didn't.")
print()
```

```
Mean math score of students who completed the Test Prep Course:
69.69553072625699
Mean math score of students who did not complete the Test Prep Course:
64.0778816199377
Mean difference: 5.617649106319291
```



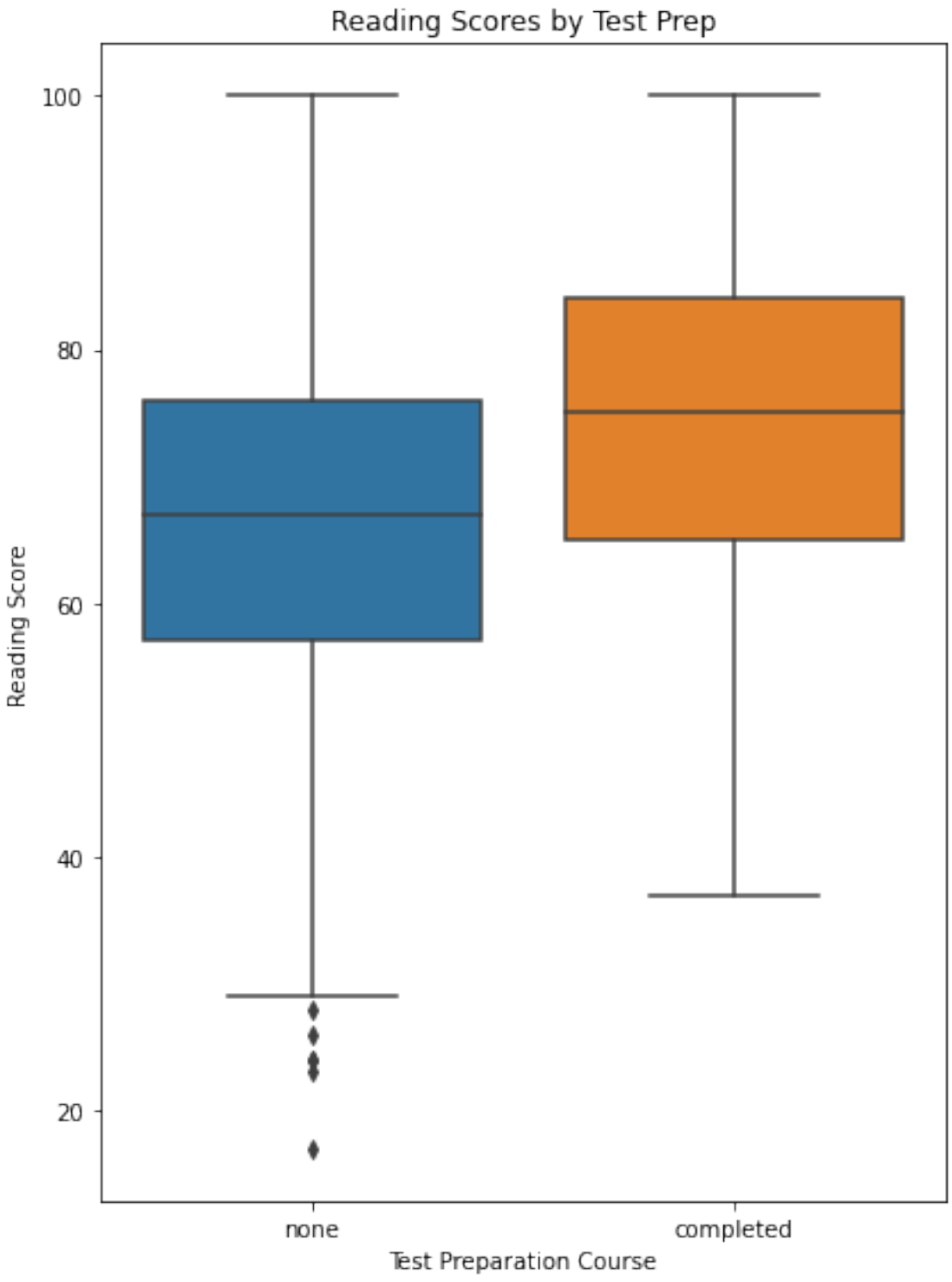

```
P-Value: 1.5359134607147415e-08
There is a statistically significant difference between math scores of students
who completed the test prep course vs those who didn't.
```

Students who completed the test prep course averaged higher with statistical significance.

[41]:
```
#Hypothesis 9: relation between test preparation course and reading score
#Null Hyp: There is no association between whether a student took the test prep␣
 ↪course and their reading score.
#Alt Hyp: There is a significant difference (5% significance threshhold)␣
 ↪between the reading scores of students who took the test prep course vs␣
 ↪those who did not.

testprep_reading_scores = student_df.reading_score[student_df.test_prep ==␣
 ↪'completed']
#print(testprep_reading_scores.describe())
noprep_reading_scores = student_df.reading_score[student_df.test_prep == 'none']
#print(noprep_reading_scores.describe())

testprep_reading_mean = np.mean(testprep_reading_scores)
noprep_reading_mean =  np.mean(noprep_reading_scores)
print("Mean reading score of students who completed the Test Prep Course: " +␣
 ↪str(testprep_reading_mean))
print("Mean reading score of students who did not complete the Test Prep Course:
 ↪ " + str(noprep_reading_mean))
print("Mean difference: " + str(testprep_reading_mean - noprep_reading_mean))

#side by side box plots for scores based on test prep
plt.figure(figsize = (6,8))
sns.boxplot(data = student_df, x = 'test_prep', y = 'reading_score')
plt.ylabel("Reading Score")
plt.xlabel("Test Preparation Course")
plt.title("Reading Scores by Test Prep")
plt.tight_layout()
plt.savefig('testprep_reading.png')
plt.show()

#Two-sample T-Test
tstat, pval = ttest_ind(testprep_reading_scores, noprep_reading_scores)
print("P-Value: " + str(pval))
if pval < 0.05:
    print("There is a statistically significant difference between reading␣
 ↪scores of students who completed the test prep course vs those who didn't.")
    if testprep_reading_mean > noprep_reading_mean:
        print("Students who completed the test prep course averaged higher with␣
 ↪statistical significance.")
    else:
        print("Students who did NOT complete the test prep course averaged␣
 ↪higher with statistical significance.")
```

```
else:
    print("There is NOT a statistically significant difference between reading␣
 ↪scores of students who completed the test prep course vs those who didn't.")
print()
```

```
Mean reading score of students who completed the Test Prep Course:
73.89385474860335
Mean reading score of students who did not complete the Test Prep Course:
66.53426791277259
Mean difference: 7.359586835830754
```



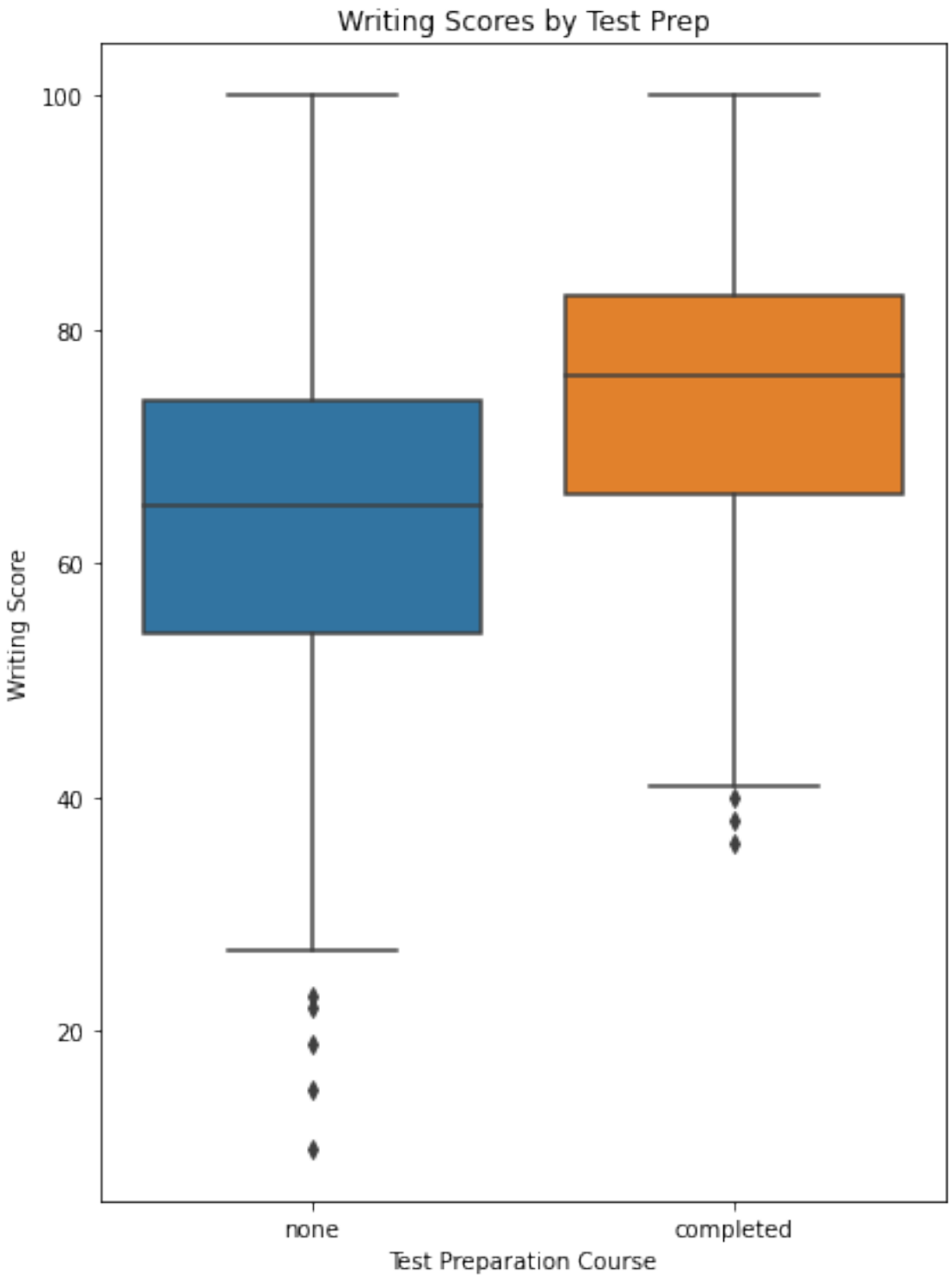

```
P-Value: 9.081783336892205e-15
There is a statistically significant difference between reading scores of
students who completed the test prep course vs those who didn't.
```

Students who completed the test prep course averaged higher with statistical significance.

[42]:
```
#Hypothesis 10: relation between test preparation course and writing score
#Null Hyp: There is no association between whether a student took the test prep␣
 ↪course and their writing score.
#Alt Hyp: There is a significant difference (5% significance threshhold)␣
 ↪between the writing scores of students who took the test prep course vs␣
 ↪those who did not.

testprep_writing_scores = student_df.writing_score[student_df.test_prep ==␣
 ↪'completed']
#print(testprep_writing_scores.describe())
noprep_writing_scores = student_df.writing_score[student_df.test_prep == 'none']
#print(noprep_writing_scores.describe())

testprep_writing_mean = np.mean(testprep_writing_scores)
noprep_writing_mean =  np.mean(noprep_writing_scores)
print("Mean writing score of students who completed the Test Prep Course: " +␣
 ↪str(testprep_writing_mean))
print("Mean writing score of students who did not complete the Test Prep Course:
 ↪ " + str(noprep_writing_mean))
print("Mean difference: " + str(testprep_writing_mean - noprep_writing_mean))

#side by side box plots for scores based on test prep
plt.figure(figsize = (6,8))
sns.boxplot(data = student_df, x = 'test_prep', y = 'writing_score')
plt.ylabel("Writing Score")
plt.xlabel("Test Preparation Course")
plt.title("Writing Scores by Test Prep")
plt.tight_layout()
plt.savefig('testprep_writing.png')
plt.show()

#Two-sample T-Test
tstat, pval = ttest_ind(testprep_writing_scores, noprep_writing_scores)
print("P-Value: " + str(pval))
if pval < 0.05:
    print("There is a statistically significant difference between writing␣
 ↪scores of students who completed the test prep course vs those who didn't.")
    if testprep_writing_mean > noprep_writing_mean:
        print("Students who completed the test prep course averaged higher with␣
 ↪statistical significance.")
    else:
        print("Students who did NOT complete the test prep course averaged␣
 ↪higher with statistical significance.")
```

```
else:
    print("There is NOT a statistically significant difference between writing␣
 ↪scores of students who completed the test prep course vs those who didn't.")
print()
```

```
Mean writing score of students who completed the Test Prep Course:
74.41899441340782
Mean writing score of students who did not complete the Test Prep Course:
64.50467289719626
Mean difference: 9.914321516211558
```




```
P-Value: 3.68529173524572e-24
There is a statistically significant difference between writing scores of
students who completed the test prep course vs those who didn't.
```

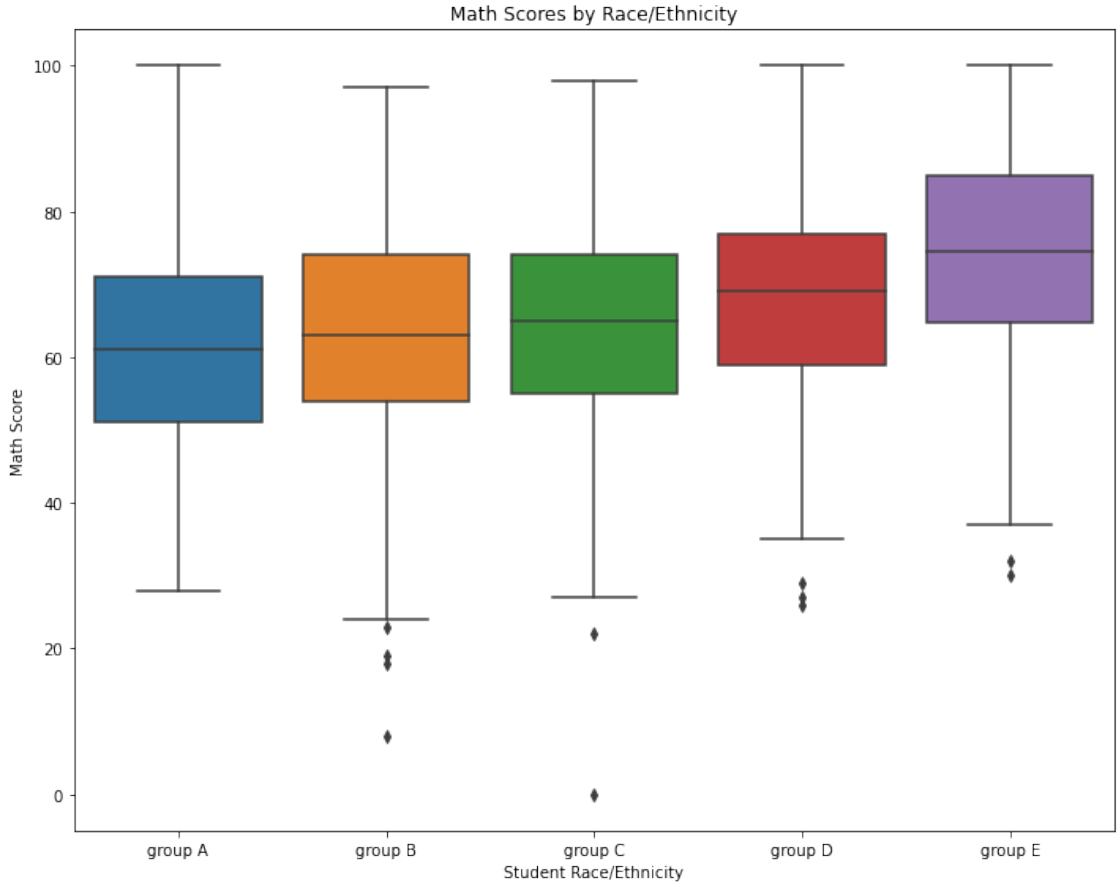
Students who completed the test prep course averaged higher with statistical significance.

[43]:
```
#Hypothesis 11: relation between race and math score
#Null Hyp: There is no association between a student's ethnicity and their math␣
 ↪score.
#Alt Hyp: There is a significant difference (5% significance threshhold)␣
 ↪between the math scores of students of different ethnicities.

#print(student_df.ethnicity.value_counts())
groupA_math_scores = student_df.math_score[student_df.ethnicity == 'group A']
groupB_math_scores = student_df.math_score[student_df.ethnicity == 'group B']
groupC_math_scores = student_df.math_score[student_df.ethnicity == 'group C']
groupD_math_scores = student_df.math_score[student_df.ethnicity == 'group D']
groupE_math_scores = student_df.math_score[student_df.ethnicity == 'group E']

#ANOVA Hyp Test
fastat, pval = f_oneway(groupA_math_scores, groupB_math_scores,␣
 ↪groupC_math_scores, groupD_math_scores, groupE_math_scores)
print("P-value: " + str(pval))
if pval < 0.5:
    print("There is a statistically significant difference in math scores among␣
 ↪the ethnic groups in this data."), print()
else:
    print("There is NOT a statistically significant difference in math scores␣
 ↪among the ethnic groups in this data."), print()

#Tukey Range Test -- which group(s) have the significant differences?
tukey_results = pairwise_tukeyhsd(student_df.math_score, student_df.ethnicity,␣
 ↪0.05)
print(tukey_results), print()

rows = tukey_results.summary().data[1:]
#print(rows)

print("There are statistically siginificant differences in math scores between:
 ↪")
for list in rows:
    group1 = list[0]
    group2 = list[1]
    significance = list[-1]
    if significance == True:
        print(group1 + " and " + group2)
print()
```

```
tukey_df = pd.DataFrame(rows, columns = ['group1',  'group2', 'meandiff',␣
 ↪'p_adj',   'lower',   'upper',  'reject'])
max_meandiff = tukey_df.meandiff.max()
max_meandiff_row = tukey_df.meandiff.idxmax()

max_diff_group1 = tukey_df.iloc[max_meandiff_row][0]
max_diff_group2 = tukey_df.iloc[max_meandiff_row][1]
print("The largest difference in math scores was " + str(max_meandiff) + "%␣
 ↪between " + str(max_diff_group1) + " and " + str(max_diff_group2))


#Side-by-side box plots
plt.figure(figsize = (10,8))
sns.boxplot(data = student_df, x = 'ethnicity', y = 'math_score', order =␣
 ↪['group A', 'group B', 'group C', 'group D', 'group E'])
plt.ylabel("Math Score")
plt.xlabel("Student Race/Ethnicity")
plt.title("Math Scores by Race/Ethnicity")
plt.tight_layout()
plt.savefig('ethnicity_math.png')
plt.show()
```

```
P-value: 1.3732194030370688e-11
There is a statistically significant difference in math scores among the ethnic
groups in this data.

 Multiple Comparison of Means - Tukey HSD, FWER=0.05
====================================================
 group1  group2 meandiff p-adj   lower   upper  reject
----------------------------------------------------
group A group B   1.8234 0.8597   -3.36  7.0068  False
group A group C   2.8347 0.4966 -2.0028  7.6723  False
group A group D   5.7334 0.0138  0.7824 10.6844   True
group A group E  12.1922  0.001  6.7215 17.6629   True
group B group C   1.0113    0.9 -2.6867  4.7094  False
group B group D     3.91 0.0441  0.0647  7.7552   True
group B group E  10.3688  0.001  5.8741 14.8635   True
group C group D   2.8986 0.1287 -0.4659  6.2632  False
group C group E   9.3575  0.001  5.2665 13.4485   True
group D group E   6.4588  0.001  2.2343 10.6834   True
----------------------------------------------------

There are statistically siginificant differences in math scores between:
group A and group D
group A and group E
group B and group D
group B and group E
```

```
group C and group E
group D and group E

The largest difference in math scores was 12.1922% between group A and group E
```

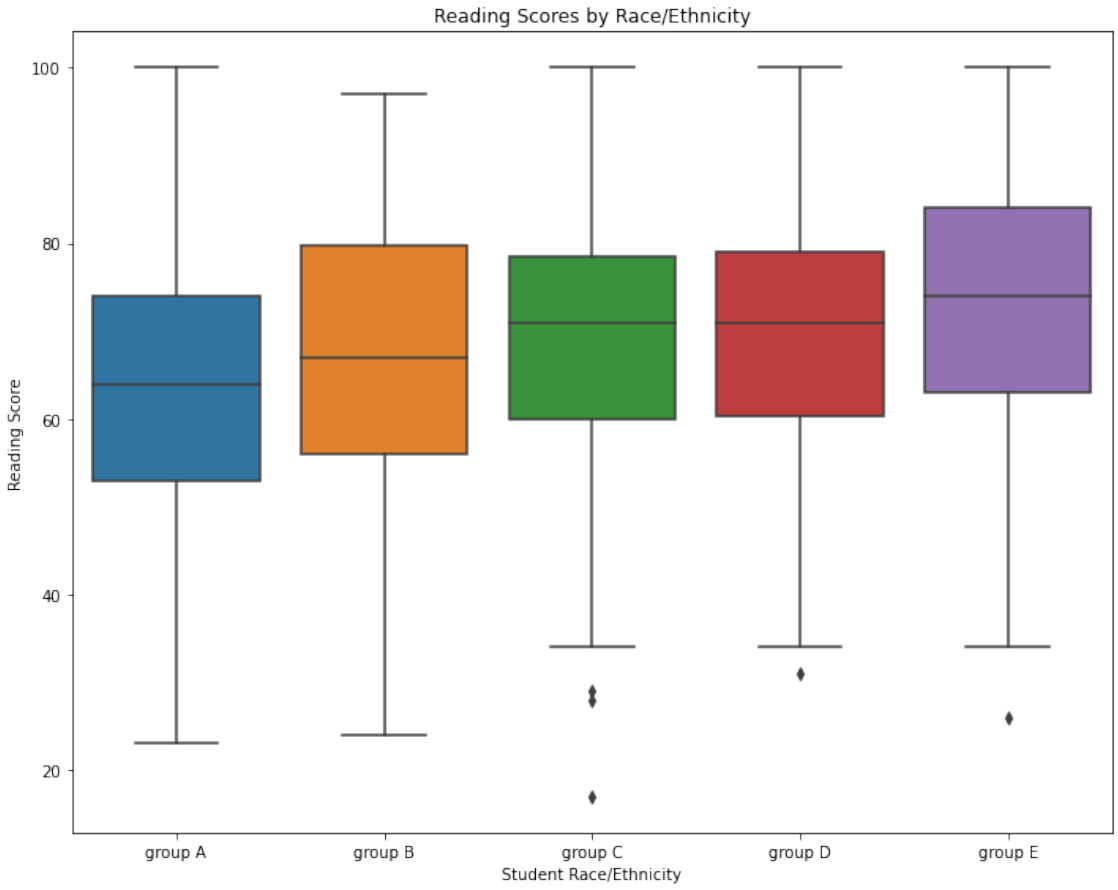


[44]:
```
#Hypothesis 12: relation between race and reading score
#Null Hyp: There is no association between a student's ethnicity and their␣
 ↪reading score.
#Alt Hyp: There is a significant difference (5% significance threshhold)␣
 ↪between the reading scores of students of different ethnicities.

#print(student_df.ethnicity.value_counts())
groupA_reading_scores = student_df.reading_score[student_df.ethnicity == 'group␣
 ↪A']
groupB_reading_scores = student_df.reading_score[student_df.ethnicity == 'group␣
 ↪B']
groupC_reading_scores = student_df.reading_score[student_df.ethnicity == 'group␣
 ↪C']
```

```
groupD_reading_scores = student_df.reading_score[student_df.ethnicity == 'group␣
 ↪D']
groupE_reading_scores = student_df.reading_score[student_df.ethnicity == 'group␣
 ↪E']

#ANOVA Hyp Test
fastat, pval = f_oneway(groupA_reading_scores, groupB_reading_scores,␣
 ↪groupC_reading_scores, groupD_reading_scores, groupE_reading_scores)
print("P-value: " + str(pval))
if pval < 0.5:
    print("There is a statistically significant difference in reading scores␣
 ↪among the ethnic groups in this data."), print()
else:
    print("There is NOT a statistically significant difference in reading␣
 ↪scores among the ethnic groups in this data."), print()

#Tukey Range Test -- which group(s) have the significant differences?
tukey_results = pairwise_tukeyhsd(student_df.reading_score, student_df.
 ↪ethnicity, 0.05)
print(tukey_results), print()

rows = tukey_results.summary().data[1:]
#print(rows)

print("There are statistically siginificant differences in reading scores␣
 ↪between:")
for list in rows:
    group1 = list[0]
    group2 = list[1]
    significance = list[-1]
    if significance == True:
        print(group1 + " and " + group2)
print()

tukey_df = pd.DataFrame(rows, columns = ['group1',  'group2', 'meandiff',␣
 ↪'p_adj',   'lower',   'upper',  'reject'])
max_meandiff = tukey_df.meandiff.max()
max_meandiff_row = tukey_df.meandiff.idxmax()

max_diff_group1 = tukey_df.iloc[max_meandiff_row][0]
max_diff_group2 = tukey_df.iloc[max_meandiff_row][1]
print("The largest difference in reading scores was " + str(max_meandiff) + "%␣
 ↪between " + str(max_diff_group1) + " and " + str(max_diff_group2))


#Side-by-side box plots
```

```
plt.figure(figsize = (10,8))
sns.boxplot(data = student_df, x = 'ethnicity', y = 'reading_score', order =␣
 ↪['group A', 'group B', 'group C', 'group D', 'group E'])
plt.ylabel("Reading Score")
plt.xlabel("Student Race/Ethnicity")
plt.title("Reading Scores by Race/Ethnicity")
plt.tight_layout()
plt.savefig('ethnicity_reading.png')
plt.show()
```

```
P-value: 0.0001780089103235947
There is a statistically significant difference in reading scores among the
ethnic groups in this data.

 Multiple Comparison of Means - Tukey HSD, FWER=0.05
=====================================================
 group1  group2 meandiff p-adj   lower   upper  reject
-----------------------------------------------------
group A group B   2.6785 0.5875 -2.3998  7.7567  False
group A group C   4.4293 0.0801 -0.3101  9.1687  False
group A group D   5.3564 0.0219  0.5058 10.2069   True
group A group E   8.3544  0.001  2.9947 13.7141   True
group B group C   1.7508  0.656 -1.8722  5.3738  False
group B group D   2.6779 0.2956 -1.0893  6.4451  False
group B group E   5.6759 0.0041  1.2724 10.0794   True
group C group D   0.9271    0.9 -2.3692  4.2234  False
group C group E   3.9251 0.0583 -0.0829  7.9331  False
group D group E    2.998 0.2768 -1.1408  7.1369  False
-----------------------------------------------------

There are statistically siginificant differences in reading scores between:
group A and group D
group A and group E
group B and group E

The largest difference in reading scores was 8.3544% between group A and group E
```

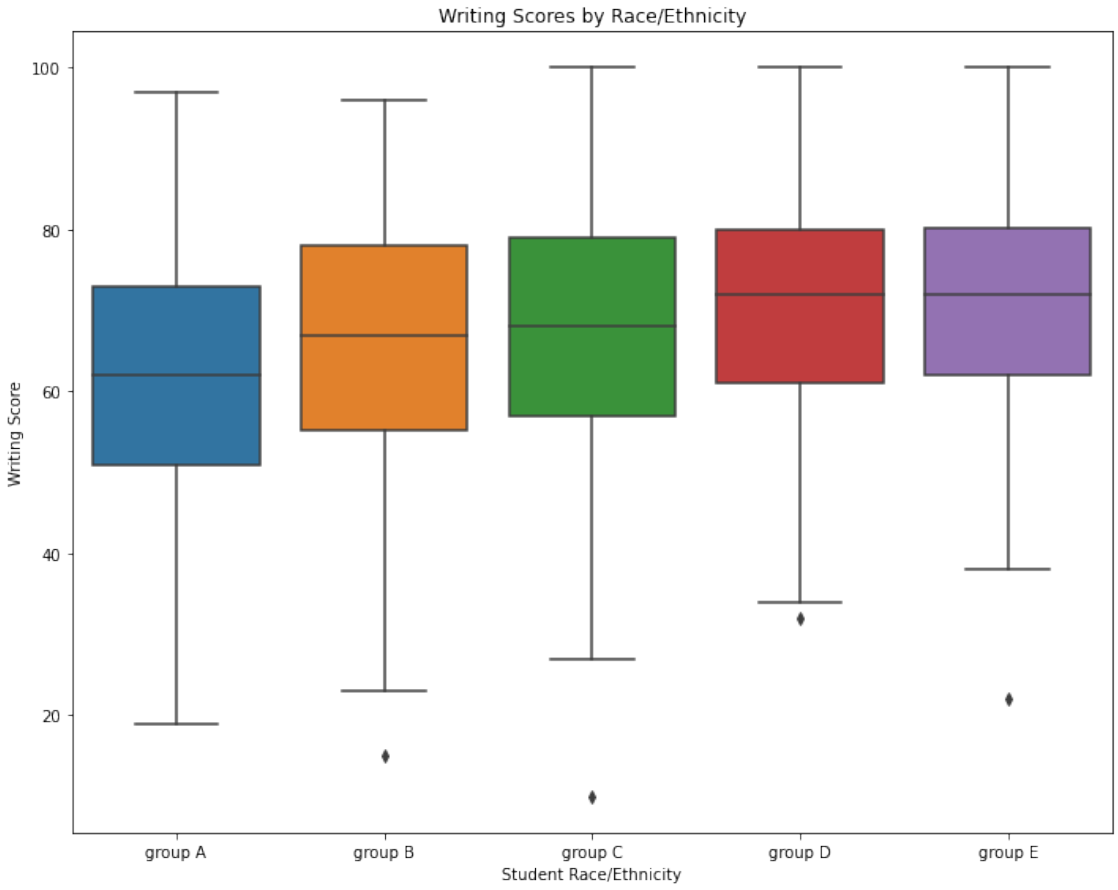


[45]:
```
#Hypothesis 13: relation between race and writing score
#Null Hyp: There is no association between a student's ethnicity and their␣
 ↪writing score.
#Alt Hyp: There is a significant difference (5% significance threshhold)␣
 ↪between the writing scores of students of different ethnicities.

#print(student_df.ethnicity.value_counts())
groupA_writing_scores = student_df.writing_score[student_df.ethnicity == 'group␣
 ↪A']
groupB_writing_scores = student_df.writing_score[student_df.ethnicity == 'group␣
 ↪B']
groupC_writing_scores = student_df.writing_score[student_df.ethnicity == 'group␣
 ↪C']
groupD_writing_scores = student_df.writing_score[student_df.ethnicity == 'group␣
 ↪D']
groupE_writing_scores = student_df.writing_score[student_df.ethnicity == 'group␣
 ↪E']

#ANOVA Hyp Test
```

```
fastat, pval = f_oneway(groupA_writing_scores, groupB_writing_scores,␣
 ↪groupC_writing_scores, groupD_writing_scores, groupE_writing_scores)
print("P-value: " + str(pval))
if pval < 0.5:
    print("There is a statistically significant difference in writing scores␣
 ↪among the ethnic groups in this data."), print()
else:
    print("There is NOT a statistically significant difference in writing␣
 ↪scores among the ethnic groups in this data."), print()

#Tukey Range Test -- which group(s) have the significant differences?
tukey_results = pairwise_tukeyhsd(student_df.writing_score, student_df.
 ↪ethnicity, 0.05)
print(tukey_results), print()

rows = tukey_results.summary().data[1:]
#print(rows)

print("There are statistically siginificant differences in writing scores␣
 ↪between:")
for list in rows:
    group1 = list[0]
    group2 = list[1]
    significance = list[-1]
    if significance == True:
        print(group1 + " and " + group2)
print()

tukey_df = pd.DataFrame(rows, columns = ['group1',  'group2', 'meandiff',␣
 ↪'p_adj',   'lower',   'upper',  'reject'])
max_meandiff = tukey_df.meandiff.max()
max_meandiff_row = tukey_df.meandiff.idxmax()

max_diff_group1 = tukey_df.iloc[max_meandiff_row][0]
max_diff_group2 = tukey_df.iloc[max_meandiff_row][1]
print("The largest difference in writing scores was " + str(max_meandiff) + "%␣
 ↪between " + str(max_diff_group1) + " and " + str(max_diff_group2))


#Side-by-side box plots
plt.figure(figsize = (10,8))
sns.boxplot(data = student_df, x = 'ethnicity', y = 'writing_score', order =␣
 ↪['group A', 'group B', 'group C', 'group D', 'group E'])
plt.ylabel("Writing Score")
plt.xlabel("Student Race/Ethnicity")
plt.title("Writing Scores by Race/Ethnicity")
```

```
plt.tight_layout()
plt.savefig('ethnicity_writing.png')
plt.show()
```

```
P-value: 1.0979189070067382e-05
There is a statistically significant difference in writing scores among the
ethnic groups in this data.

 Multiple Comparison of Means - Tukey HSD, FWER=0.05
=====================================================
 group1  group2 meandiff p-adj   lower   upper  reject
-----------------------------------------------------
group A group B   2.9258 0.5444 -2.3436  8.1953  False
group A group C   5.1534 0.0346  0.2356 10.0712   True
group A group D   7.4709  0.001  2.4377  12.504   True
group A group E    8.733  0.001  3.1715 14.2945   True
group B group C   2.2276 0.4857 -1.5318   5.987  False
group B group D    4.545 0.0133   0.636  8.4541   True
group B group E   5.8071 0.0049  1.2379 10.3764   True
group C group D   2.3175 0.3448 -1.1029  5.7378  False
group C group E   3.5796 0.1294 -0.5793  7.7385  False
group D group E   1.2621    0.9 -3.0326  5.5568  False
-----------------------------------------------------

There are statistically siginificant differences in writing scores between:
group A and group C
group A and group D
group A and group E
group B and group D
group B and group E

The largest difference in writing scores was 8.733% between group A and group E
```


Writing Scores by Race/Ethnicity
Writing Score
100
80
60
40
20
group A
group B
group C
group D
group E
Student Race/Ethnicity