Data_Processing

August 7, 2024

1 Data Mining

The below blocks of code contain the analysis conducted on the data set.

[1]:

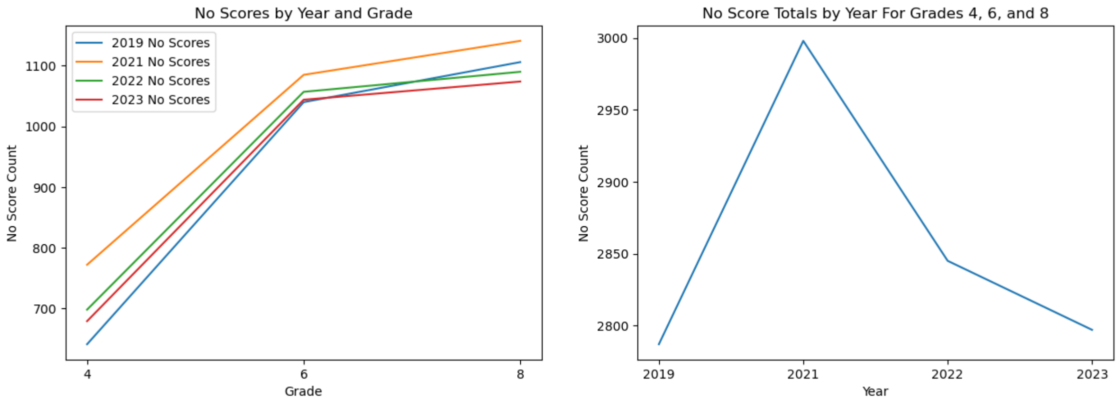
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import math

data = pd.read_csv('all_school_data_2019_2023.csv', sep=",", header=0)
grades = ['3','4','5','6','7','8']
years = ['2019', '2021', '2022', '2023']
```

[2]:

```
## This code block looks at the number of schools not required to submit scores.
 ↪ Using grades 4, 6, and 8 because those all have reporting since 2019
noScores_Grade4 = []
noScores_Grade6 = []
noScores_Grade8 = []

# import numpy as np
# values = np.array([1,2,3,1,2,4,5,6,3,2,1])
# searchval = 3
# ii = np.where(values == searchval)[0]
subGrades = ['4', '6', '8']
for year in years:
    for grade in subGrades:
        allScores = np.array(data[year+' Grade '+grade+' meets or exceeds␣
 ↪expectations'].tolist())
        noScoreCount = len(np.where(np.isnan(allScores))[0])
        if grade == '4':
            noScores_Grade4.append(noScoreCount)
        if grade == '6':
            noScores_Grade6.append(noScoreCount)
        if grade == '8':
            noScores_Grade8.append(noScoreCount)
```

```
totals = [sum([noScores_Grade4[0], noScores_Grade6[0], noScores_Grade8[0]]),␣
 ↪sum([noScores_Grade4[1], noScores_Grade6[1], noScores_Grade8[1]]),␣
 ↪sum([noScores_Grade4[2], noScores_Grade6[2], noScores_Grade8[2]]),␣
 ↪sum([noScores_Grade4[3], noScores_Grade6[3], noScores_Grade8[3]])]

fig, ((ax1, ax2)) = plt.subplots(1, 2)

fig.subplots_adjust(wspace=0.2, hspace=0)
# fig.set_figheight(15)
fig.set_figwidth(15)

ax1.plot(subGrades, [noScores_Grade4[0], noScores_Grade6[0],␣
 ↪noScores_Grade8[0]], label="2019 No Scores")
ax1.plot(subGrades, [noScores_Grade4[1], noScores_Grade6[1],␣
 ↪noScores_Grade8[1]], label="2021 No Scores")
ax1.plot(subGrades, [noScores_Grade4[2], noScores_Grade6[2],␣
 ↪noScores_Grade8[2]], label="2022 No Scores")
ax1.plot(subGrades, [noScores_Grade4[3], noScores_Grade6[3],␣
 ↪noScores_Grade8[3]], label="2023 No Scores")
ax1.set_xlabel('Grade')
ax1.set_ylabel('No Score Count')
ax1.legend(loc="best")
ax1.set_title('No Scores by Year and Grade')

ax2.plot(
    years,
    totals,
    label="Total No Scores")
ax2.set_xlabel('Year')
ax2.set_ylabel('No Score Count')
ax2.set_title('No Score Totals by Year For Grades 4, 6, and 8')
```

```
[2]: Text(0.5, 1.0, 'No Score Totals by Year For Grades 4, 6, and 8')
```



[62]:

```
## This code block conducts the contingency analysis for each year, each grade,␣
 ↪to determine the correlation
## between spend and performance.

## Helper Functions
def calcX2Val(first, second):
    return ((first - second)**2) / second

def getX2Correlation(x2val, observedVal, expectedVal):
    if x2val > 1:
        if observedVal < expectedVal:
            return 'negative correlation'
        return 'positive correlation'
    return 'no correlation'

# List to store results in
x2_results = []
support_results = []
confidence_results = []
lift_results = []
below_avg = pd.DataFrame()
above_avg = pd.DataFrame()
## Calculate the lift, x2 and correlation for each grade by year
for year in years:
    for grade in ['4', '6', '8']:
        ## First, create a copy where all nans have been removed
        this_data = data[(data[year+' Grade '+grade+' Mean Scale Score'].
 ↪notnull()) & (data[year+' Grade '+grade+' Mean Scale Score'] != 0.0)]
        if not this_data.empty:
            ## Get the average mean scale score
            mean_scale_score = this_data[year+' Grade '+grade+' Mean Scale␣
 ↪Score'].mean()
            ## Get the average spend per student across all schools in 2023
            average_spend_per_student = this_data[year+' Spend Per Student'].
 ↪mean()
            ## Get the contingency table values
            above_avg_mss_above_avg_sps = len(this_data[(this_data[year+' Grade␣
 ↪'+grade+' Mean Scale Score'] >= mean_scale_score) & (this_data[year+' Spend␣
 ↪Per Student'] >= average_spend_per_student)].values)
            above_avg_mss_below_avg_sps = len(this_data[(this_data[year+' Grade␣
 ↪'+grade+' Mean Scale Score'] >= mean_scale_score) & (this_data[year+' Spend␣
 ↪Per Student'] < average_spend_per_student)].values)
            below_avg_mss_above_avg_sps = len(this_data[(this_data[year+' Grade␣
 ↪'+grade+' Mean Scale Score'] <  mean_scale_score) & (this_data[year+' Spend␣
 ↪Per Student'] >= average_spend_per_student)].values)
```

```
            below_avg_mss_below_avg_sps = len(this_data[(this_data[year+' Grade '+grade+' Mean Scale Score'] <  mean_scale_score) & (this_data[year+' Spend Per Student'] < average_spend_per_student)].values)

            above_avg = this_data[(this_data[year+' Grade '+grade+' Mean Scale Score'] >= mean_scale_score) & (this_data[year+' Spend Per Student'] < average_spend_per_student)]
            below_avg = this_data[(this_data[year+' Grade '+grade+' Mean Scale Score'] <  mean_scale_score) & (this_data[year+' Spend Per Student'] >= average_spend_per_student)]



            row_sum_1 = above_avg_mss_above_avg_sps+above_avg_mss_below_avg_sps
            row_sum_2 = below_avg_mss_above_avg_sps+below_avg_mss_below_avg_sps
            col_sum_1 = above_avg_mss_above_avg_sps+below_avg_mss_above_avg_sps
            col_sum_2 = above_avg_mss_below_avg_sps+below_avg_mss_below_avg_sps
            total = row_sum_1 + row_sum_2

            ## Get the probabilities
            prob_above_mss_and_above_sps = above_avg_mss_above_avg_sps / total
            prob_above_avg_mss = row_sum_1 / total
            prob_above_avg_sps = col_sum_1 / total

            ## Calculate Lift
            lift = (prob_above_mss_and_above_sps)/(prob_above_avg_mss * prob_above_avg_sps)
            ## Calculate support
            support = prob_above_mss_and_above_sps
            ## Calculate confidence
            confidence = above_avg_mss_above_avg_sps / row_sum_1
            ## Calculate x2 value
            e_11 = row_sum_1 * col_sum_1 / total
            e_12 = row_sum_1 * col_sum_2 / total
            e_21 = row_sum_2 * col_sum_1 / total
            e_22 = row_sum_2 * col_sum_2 / total
            x_2 = calcX2Val(above_avg_mss_above_avg_sps, e_11) + calcX2Val(above_avg_mss_below_avg_sps, e_12) + calcX2Val(below_avg_mss_above_avg_sps, e_21) + calcX2Val(below_avg_mss_below_avg_sps, e_22)
            x2_results.append(x_2)
            support_results.append(support*100)
            confidence_results.append(confidence*100)
            lift_results.append(lift)
            ## Print out the table
            contingency_table = pd.DataFrame([
                [above_avg_mss_above_avg_sps, above_avg_mss_below_avg_sps, row_sum_1],
                [below_avg_mss_above_avg_sps, below_avg_mss_below_avg_sps,␣
 ↪row_sum_2],
                [col_sum_1, col_sum_2, total],
            ],columns=['>= Avg SPS', '< Avg SPS', 'Row Sum'], index=['>= Avg␣
 ↪MSS', '< Avg MSS', 'Col Sum'])
            print(year+' Grade '+grade+' Contingency Table')
            print(contingency_table)
            print('Mean Spend Per Student: ', round(average_spend_per_student))
            print('Mean Mean Scale Score: ', round(mean_scale_score))
            print('Lift Calculation: ',round(lift,4))
            print('Correlation: ', getX2Correlation(x_2,␣
 ↪above_avg_mss_above_avg_sps, e_11))
            print('X^2 Calc: ', round(x_2,4))
            print('Support: ', round(support*100, 2), '%')
            print('Confidence: ', round(confidence*100, 2), '%')
            print('')
           ␣
 ↪print('--------------------------------------------------------------')

fig, ax1 = plt.subplots()

color = 'tab:blue'
ax1.set_xlabel('Year')
ax1.set_ylabel('X^2 Correlation', color=color)
ax1.plot(years, x2_results[0::3], label="Grade 4", color='green')
ax1.plot(years, x2_results[1::3], label="Grade 6", color='red')
ax1.plot(years, x2_results[2::3], label="Grade 8", color='blue')
ax1.legend(loc="upper right")
ax1.tick_params(axis='y', labelcolor=color)
ax1.set_title('X^2 Correlation By Year and Grade')

fig.tight_layout()  # otherwise the right y-label is slightly clipped
plt.show()
```

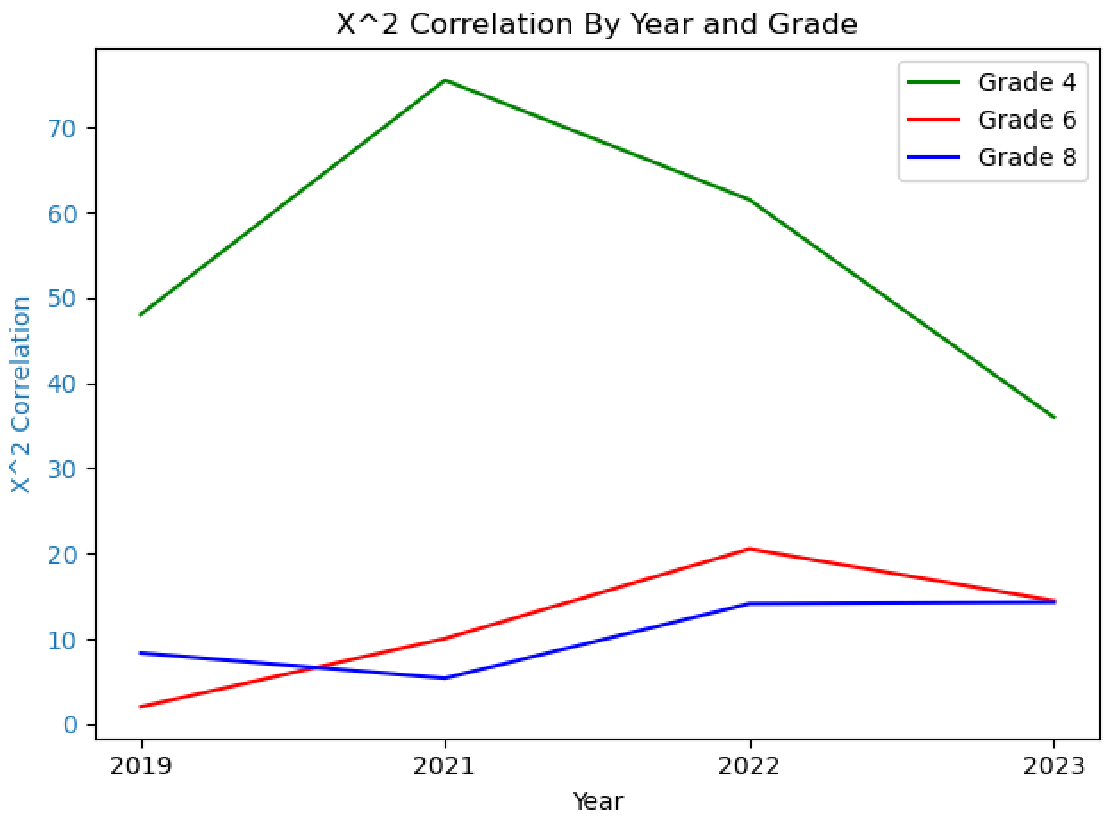
```
2019 Grade 4 Contingency Table
            >= Avg SPS  < Avg SPS  Row Sum
>= Avg MSS         182        274      456
< Avg MSS          310        187      497
Col Sum            492        461      953
Mean Spend Per Student:  12087
Mean Mean Scale Score:  734
Lift Calculation:  0.7731
Correlation:  negative correlation
X^2 Calc:  48.0445
Support:  19.1 %
Confidence:  39.91 %
```

```
--------------------------------------------------------------
2019 Grade 6 Contingency Table
            >= Avg SPS  < Avg SPS  Row Sum
>= Avg MSS         119        135      254
< Avg MSS          149        132      281
Col Sum            268        267      535
Mean Spend Per Student:  11409
Mean Mean Scale Score:  733
Lift Calculation:  0.9353
Correlation:  negative correlation
X^2 Calc:  2.0345
Support:  22.24 %
Confidence:  46.85 %

--------------------------------------------------------------
2019 Grade 8 Contingency Table
            >= Avg SPS  < Avg SPS  Row Sum
>= Avg MSS          95        136      231
< Avg MSS          126        105      231
Col Sum            221        241      462
Mean Spend Per Student:  11531
Mean Mean Scale Score:  735
Lift Calculation:  0.8597
Correlation:  negative correlation
X^2 Calc:  8.336
Support:  20.56 %
Confidence:  41.13 %

--------------------------------------------------------------
2021 Grade 4 Contingency Table
            >= Avg SPS  < Avg SPS  Row Sum
>= Avg MSS         150        308      458
< Avg MSS          284        179      463
Col Sum            434        487      921
Mean Spend Per Student:  12908
Mean Mean Scale Score:  727
Lift Calculation:  0.695
Correlation:  negative correlation
X^2 Calc:  75.5188
Support:  16.29 %
Confidence:  32.75 %

--------------------------------------------------------------
2021 Grade 6 Contingency Table
            >= Avg SPS  < Avg SPS  Row Sum
>= Avg MSS         105        151      256
< Avg MSS          147        121      268
Col Sum            252        272      524
```

```
Mean Spend Per Student:  12037
Mean Mean Scale Score:  726
Lift Calculation:  0.8529
Correlation:  negative correlation
X^2 Calc:  10.0393
Support:  20.04 %
Confidence:  41.02 %

--------------------------------------------------------------
2021 Grade 8 Contingency Table
            >= Avg SPS  < Avg SPS  Row Sum
>= Avg MSS          89        122      211
< Avg MSS          127        112      239
Col Sum            216        234      450
Mean Spend Per Student:  11944
Mean Mean Scale Score:  729
Lift Calculation:  0.8788
Correlation:  negative correlation
X^2 Calc:  5.3912
Support:  19.78 %
Confidence:  42.18 %

--------------------------------------------------------------
2022 Grade 4 Contingency Table
            >= Avg SPS  < Avg SPS  Row Sum
>= Avg MSS         168        312      480
< Avg MSS          298        198      496
Col Sum            466        510      976
Mean Spend Per Student:  14087
Mean Mean Scale Score:  730
Lift Calculation:  0.733
Correlation:  negative correlation
X^2 Calc:  61.5027
Support:  17.21 %
Confidence:  35.0 %

--------------------------------------------------------------
2022 Grade 6 Contingency Table
            >= Avg SPS  < Avg SPS  Row Sum
>= Avg MSS         110        159      269
< Avg MSS          177        118      295
Col Sum            287        277      564
Mean Spend Per Student:  13197
Mean Mean Scale Score:  728
Lift Calculation:  0.8036
Correlation:  negative correlation
X^2 Calc:  20.5548
Support:  19.5 %
```

```
Confidence:  40.89 %

--------------------------------------------------------------
2022 Grade 8 Contingency Table
            >= Avg SPS  < Avg SPS  Row Sum
>= Avg MSS          98        141      239
< Avg MSS          159        117      276
Col Sum            257        258      515
Mean Spend Per Student:  13249
Mean Mean Scale Score:  730
Lift Calculation:  0.8217
Correlation:  negative correlation
X^2 Calc:  14.1258
Support:  19.03 %
Confidence:  41.0 %

--------------------------------------------------------------
2023 Grade 4 Contingency Table
            >= Avg SPS  < Avg SPS  Row Sum
>= Avg MSS         181        300      481
< Avg MSS          288        220      508
Col Sum            469        520      989
Mean Spend Per Student:  15541
Mean Mean Scale Score:  732
Lift Calculation:  0.7935
Correlation:  negative correlation
X^2 Calc:  36.0089
Support:  18.3 %
Confidence:  37.63 %

--------------------------------------------------------------
2023 Grade 6 Contingency Table
            >= Avg SPS  < Avg SPS  Row Sum
>= Avg MSS         112        160      272
< Avg MSS          174        131      305
Col Sum            286        291      577
Mean Spend Per Student:  14704
Mean Mean Scale Score:  729
Lift Calculation:  0.8307
Correlation:  negative correlation
X^2 Calc:  14.4906
Support:  19.41 %
Confidence:  41.18 %

--------------------------------------------------------------
2023 Grade 8 Contingency Table
            >= Avg SPS  < Avg SPS  Row Sum
>= Avg MSS          97        143      240
```

```
< Avg MSS           164         124       288
Col Sum             261         267       528
Mean Spend Per Student:  14734
Mean Mean Scale Score:  730
Lift Calculation:  0.8176
Correlation:  negative correlation
X^2 Calc:  14.3059
Support:  18.37 %
Confidence:  40.42 %

--------------------------------------------------------------
```



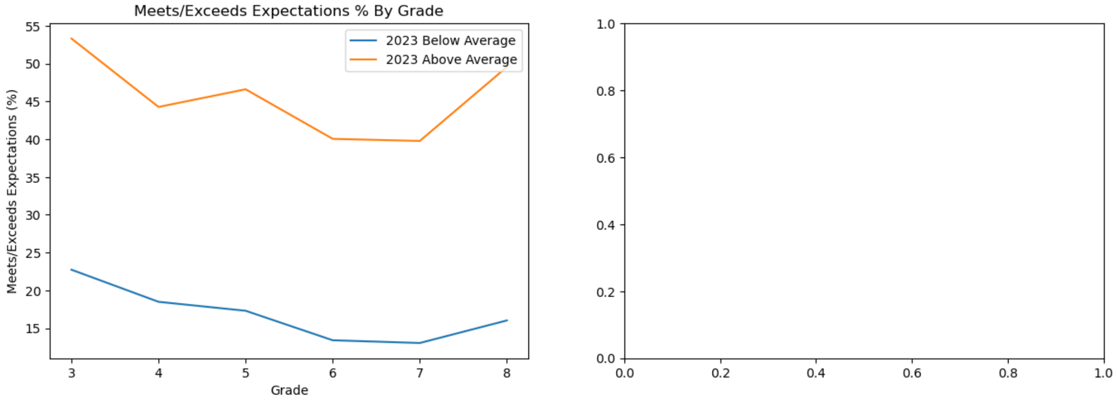
[64]:

```
## This plots the performance of 2023 schools for those that were above average␣
 ↪MSS and below average SPS, versus those below average MSS and above average␣
 ↪SPS.
def getMeanMeetsOrExceeds(data, grades, years):
    meanMeetsOrExceeds = []
    for year in years:
        for grade in grades:
            # Don't remove 0.0 scores, because some schools actually did report␣
 ↪values of 0
```

```
            meanMeetsOrExceeds.append(data[(data[year+' Grade '+grade+' meets␣
 ↪or exceeds expectations'] != 'N/A')][year+' Grade '+grade+' meets or exceeds␣
 ↪expectations'].mean())
    # Order is year, grade as in 2019 - 3, 2019-4, etc
    return meanMeetsOrExceeds

# Remove nans
meanMeetsOrExceedsBelow = np.nan_to_num(np.
 ↪array(getMeanMeetsOrExceeds(below_avg, grades, years)))
meanMeetsOrExceedsAbove = np.nan_to_num(np.
 ↪array(getMeanMeetsOrExceeds(above_avg, grades, years)))

fig, ((ax1, ax2)) = plt.subplots(1, 2)

fig.subplots_adjust(wspace=0.2, hspace=0)
fig.set_figwidth(15)

# Showing only 2019, 2022, and 2023
# ax1.plot(grades, meanMeetsOrExceedsBelow[0:6], label="2019")
# ax1.plot(grades, meanMeetsOrExceedsBelow[12:18], label="2022")
ax1.plot(grades, meanMeetsOrExceedsBelow[18:], label="2023 Below Average")
ax1.plot(grades, meanMeetsOrExceedsAbove[18:], label="2023 Above Average")
ax1.set_xlabel('Grade')
ax1.set_ylabel('Meets/Exceeds Expectations (%)')
ax1.legend(loc="upper right")
ax1.set_title('Meets/Exceeds Expectations % By Grade')
```

[64]:

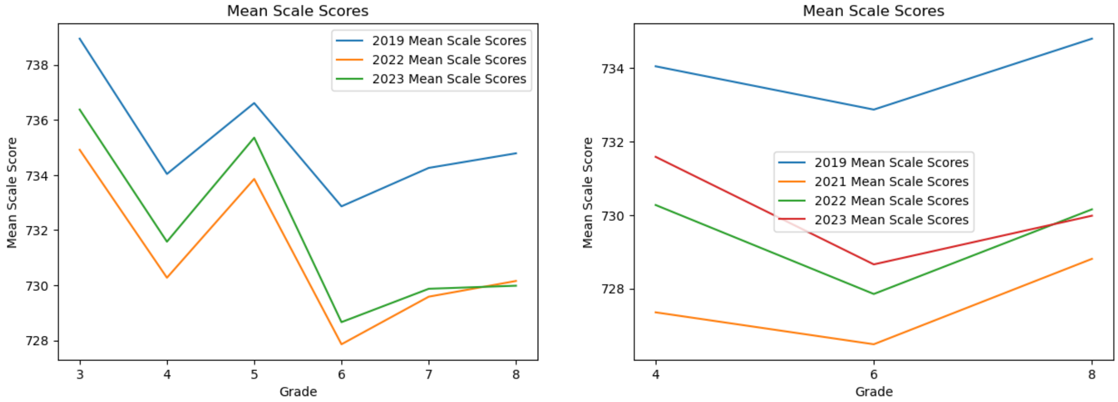
```
Text(0.5, 1.0, 'Meets/Exceeds Expectations % By Grade')
```



[3]:

```
## This code block looks at the Mean Scale Scores by grade, for each year
# Generate the average scores
def getMeanScaleScores(data, grades, years):
    meanScaleScores = []
    for year in years:
        for grade in grades:
            ## Here, remove the N/As and the 0.0, because they totally skew the␣
 ↪results
            meanScaleScores.append(data[(data[year+' Grade '+grade+' Mean Scale␣
 ↪Score'].notnull()) & (data[year+' Grade '+grade+' Mean Scale Score'] != 0.
 ↪0)][year+' Grade '+grade+' Mean Scale Score'].mean())
    # Order is year, grade as in 2019 - 3, 2019-4, etc
    return meanScaleScores

# Remove nans
meanScaleScores = np.nan_to_num(np.array(getMeanScaleScores(data, grades,␣
 ↪years)))

fig, ((ax1, ax2)) = plt.subplots(1, 2)

fig.subplots_adjust(wspace=0.2, hspace=0)
# fig.set_figheight(15)
fig.set_figwidth(15)

# Showing only 2019, 2022, and 2023
ax1.plot(grades, meanScaleScores[0:6], label="2019 Mean Scale Scores")
ax1.plot(grades, meanScaleScores[12:18], label="2022 Mean Scale Scores")
ax1.plot(grades, meanScaleScores[18:], label="2023 Mean Scale Scores")
ax1.set_xlabel('Grade')
ax1.set_ylabel('Mean Scale Score')
ax1.legend(loc="upper right")
ax1.set_title('Mean Scale Scores')

meanScaleScoresAmended = meanScaleScores[1::2]

# Remove grades 3, 5, 7 and show for years 2019, 2021, 2022, 2023
ax2.plot(['4','6','8'], meanScaleScoresAmended[0:3], label="2019 Mean Scale␣
 ↪Scores")
ax2.plot(['4','6','8'], meanScaleScoresAmended[3:6], label="2021 Mean Scale␣
 ↪Scores")
ax2.plot(['4','6','8'], meanScaleScoresAmended[6:9], label="2022 Mean Scale␣
 ↪Scores")
ax2.plot(['4','6','8'], meanScaleScoresAmended[9:], label="2023 Mean Scale␣
 ↪Scores")
ax2.set_xlabel('Grade')
ax2.set_ylabel('Mean Scale Score')
ax2.legend(loc="best")
ax2.set_title('Mean Scale Scores')
```

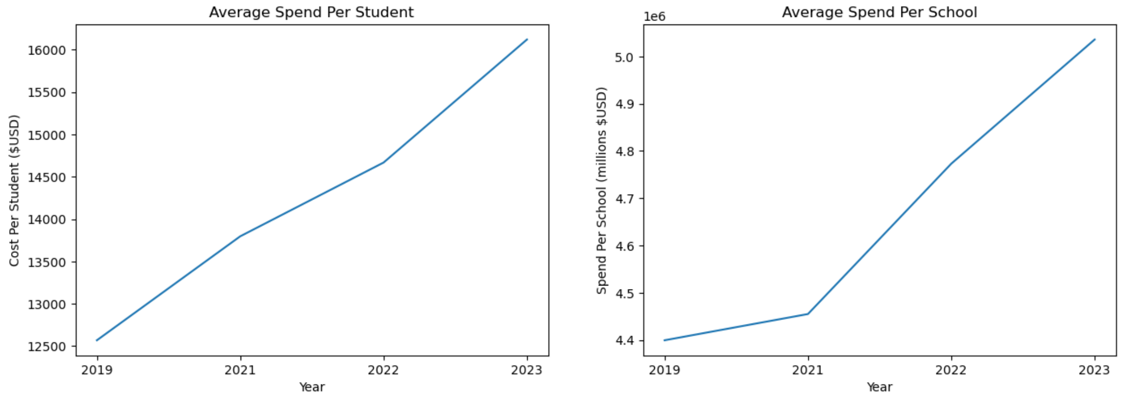
[3]:
```
Text(0.5, 1.0, 'Mean Scale Scores')
```



[4]:
```
## Now, lets look at the spend per student over the past 4 years
# Generate the average spend per student
def getMeanSpendPerStudent(data, years):
    meanSpendPerStudent = []
    for year in years:
        meanSpendPerStudent.append(data[(data[year+' Spend Per Student'] != 'N/
 ↪A') & (data[year+' Spend Per Student'] != 0.0)][year+' Spend Per Student'].
 ↪mean())
    # Order is year, spendPerStudent
    return meanSpendPerStudent

def getMeanSpendPerSchool(data, years):
    meanSpendPerSchool = []
    for year in years:
        meanSpendPerSchool.append(data[(data[year+' Total Budget'] != 'N/A') &␣
 ↪(data[year+' Total Budget'] != 0.0)][year+' Total Budget'].mean())
    # Order is year, spendPerStudent
    return meanSpendPerSchool

fig, ((ax1, ax2)) = plt.subplots(1, 2)

fig.subplots_adjust(wspace=0.2, hspace=0)
# fig.set_figheight(15)
fig.set_figwidth(15)

# Showing only 2019, 2022, and 2023
ax1.plot(years, getMeanSpendPerStudent(data, years))
ax1.set_xlabel('Year')
ax1.set_ylabel('Cost Per Student ($USD)')
ax1.set_title('Average Spend Per Student')
```

```
# Remove grades 3, 5, 7 and show for years 2019, 2021, 2022, 2023
ax2.plot(years, getMeanSpendPerSchool(data, years))
ax2.set_xlabel('Year')
ax2.set_ylabel('Spend Per School (millions $USD)')
ax2.set_title('Average Spend Per School')
```

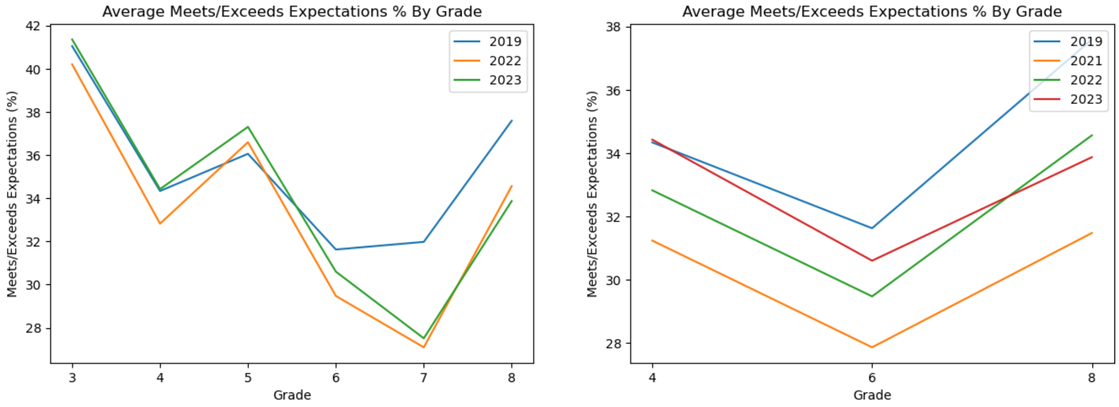
```
[4]: Text(0.5, 1.0, 'Average Spend Per School')
```



```
[5]: ## This code block plots the meets/exceeds expectations percentage for each␣
     ↪grade (average)
     # Generate the average meets/exceeds percentages
     def getMeanMeetsOrExceeds(data, grades, years):
         meanMeetsOrExceeds = []
         for year in years:
             for grade in grades:
                 # Don't remove 0.0 scores, because some schools actually did report␣
     ↪values of 0
                 meanMeetsOrExceeds.append(data[(data[year+' Grade '+grade+' meets␣
     ↪or exceeds expectations'] != 'N/A')][year+' Grade '+grade+' meets or exceeds␣
     ↪expectations'].mean())
         # Order is year, grade as in 2019 - 3, 2019-4, etc
         return meanMeetsOrExceeds

     # Remove nans
     meanMeetsOrExceeds = np.nan_to_num(np.array(getMeanMeetsOrExceeds(data, grades,␣
     ↪years)))

     fig, ((ax1, ax2)) = plt.subplots(1, 2)

     fig.subplots_adjust(wspace=0.2, hspace=0)
     fig.set_figwidth(15)
```

```
# Showing only 2019, 2022, and 2023
ax1.plot(grades, meanMeetsOrExceeds[0:6], label="2019")
ax1.plot(grades, meanMeetsOrExceeds[12:18], label="2022")
ax1.plot(grades, meanMeetsOrExceeds[18:], label="2023")
ax1.set_xlabel('Grade')
ax1.set_ylabel('Meets/Exceeds Expectations (%)')
ax1.legend(loc="upper right")
ax1.set_title('Average Meets/Exceeds Expectations % By Grade')

meanMeetsOrExceedsAmended = meanMeetsOrExceeds[1::2]

# Remove grades 3, 5, 7 and show for years 2019, 2021, 2022, 2023
ax2.plot(['4','6','8'], meanMeetsOrExceedsAmended[0:3], label="2019")
ax2.plot(['4','6','8'], meanMeetsOrExceedsAmended[3:6], label="2021")
ax2.plot(['4','6','8'], meanMeetsOrExceedsAmended[6:9], label="2022")
ax2.plot(['4','6','8'], meanMeetsOrExceedsAmended[9:], label="2023")
ax2.set_xlabel('Grade')
ax2.set_ylabel('Meets/Exceeds Expectations (%)')
ax2.legend(loc="upper right")
ax2.set_title('Average Meets/Exceeds Expectations % By Grade')
```

```
[5]: Text(0.5, 1.0, 'Average Meets/Exceeds Expectations % By Grade')
```

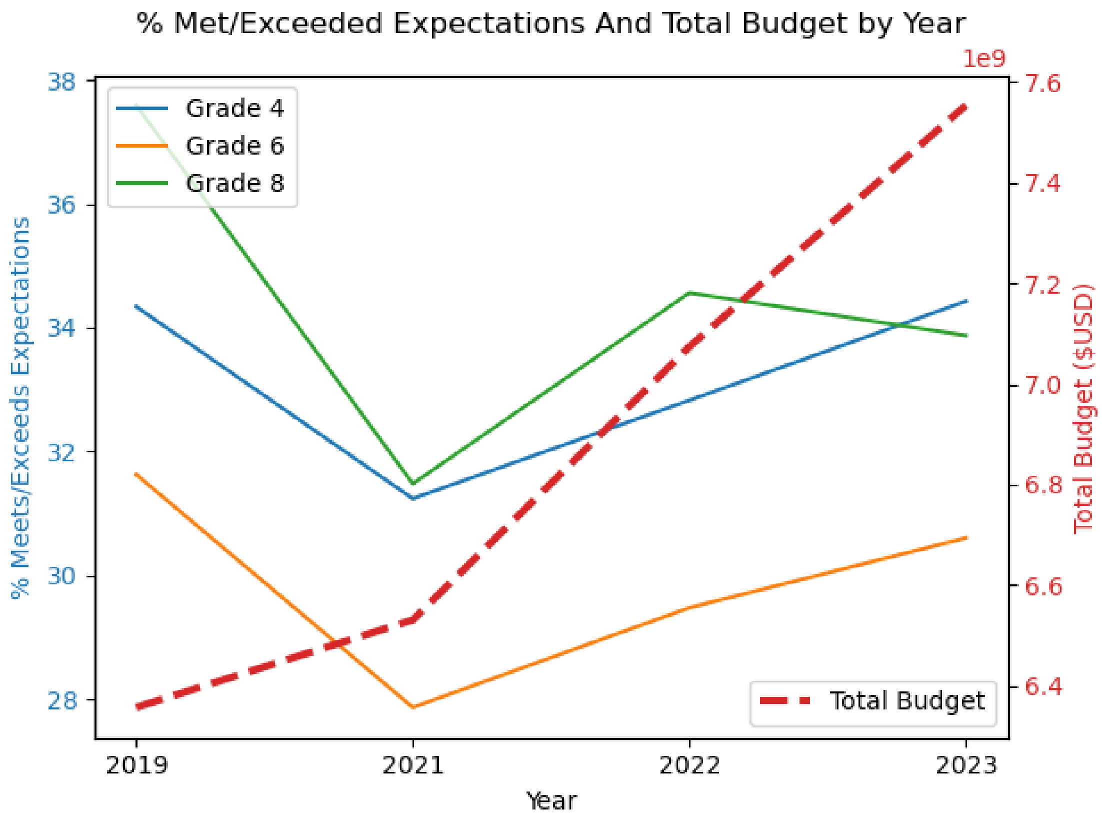


```
[65]: ## This code block plots the performance along with the total school budget
# Generate the average meets/exceeds percentages
def getMeanMeetsOrExceeds(data, grades, years):
    meanMeetsOrExceeds = []
    for year in years:
        for grade in grades:
            # Don't remove 0.0 scores, because some schools actually did report␣
 ↪values of 0
```

```
            meanMeetsOrExceeds.append(data[(data[year+' Grade '+grade+' meets␣
 ↪or exceeds expectations'] != 'N/A')][year+' Grade '+grade+' meets or exceeds␣
 ↪expectations'].mean())
    # Order is year, grade as in 2019 - 3, 2019-4, etc
    return meanMeetsOrExceeds

# Remove nans
meanMeetsOrExceeds = np.nan_to_num(np.array(getMeanMeetsOrExceeds(data, grades,␣
 ↪years)))

meanMeetsOrExceedsAmended = meanMeetsOrExceeds[1::2]

## Get the spend per student
def getTotalBudget(data, years):
    totalBudget = []
    for year in years:
        totalBudget.append(data[(data[year+' Total Budget'] != 'N/A') &␣
 ↪(data[year+' Total Budget'] != 0.0)][year+' Total Budget'].sum())
    # Order is year, spendPerStudent
    return totalBudget

def getPercentChange(data):
    change = []
    count = 0
    for val in data:
        if count == 0:
            change.append(0)
        else:
            change.append(round(((data[count] - data[count - 1])/data[count -␣
 ↪1])*100, 3))
        count += 1
    return change

totalBudget = getTotalBudget(data, years)
grade4 = meanMeetsOrExceedsAmended[0::3]
grade6 = meanMeetsOrExceedsAmended[1::3]
grade8 = meanMeetsOrExceedsAmended[2::3]
print('Grade 4 Percent Change: ', getPercentChange(grade4))
print('Grade 6 Percent Change: ', getPercentChange(grade6))
print('Grade 8 Percent Change: ', getPercentChange(grade8))
print('Total Budget Percent Change: ', getPercentChange(totalBudget))

fig, ax1 = plt.subplots()

color = 'tab:blue'
ax1.set_xlabel('Year')
ax1.set_ylabel('% Meets/Exceeds Expectations', color=color)
```

```
ax1.plot(years, grade4, label="Grade 4")
ax1.plot(years, grade6, label="Grade 6")
ax1.plot(years, grade8, label="Grade 8")
ax1.legend(loc="upper left")
ax1.tick_params(axis='y', labelcolor=color)
ax1.set_title('% Met/Exceeded Expectations And Total Budget by Year')

ax2 = ax1.twinx()  # instantiate a second Axes that shares the same x-axis

color = 'tab:red'
ax2.set_ylabel('Total Budget ($USD)', color=color)  # we already handled the␣
 ↪x-label with ax1
ax2.plot(years, getTotalBudget(data, years), color=color, label="Total Budget",␣
 ↪linestyle='dashed', linewidth=3.0)
ax2.legend(loc="lower right")
ax2.tick_params(axis='y', labelcolor=color)

fig.tight_layout()  # otherwise the right y-label is slightly clipped
plt.show()
```

```
Grade 4 Percent Change:  [0, -9.035, 5.086, 4.876]
Grade 6 Percent Change:  [0, -11.899, 5.777, 3.827]
Grade 8 Percent Change:  [0, -16.27, 9.8, -1.995]
Total Budget Percent Change:  [0, 2.734, 8.312, 6.784]
```

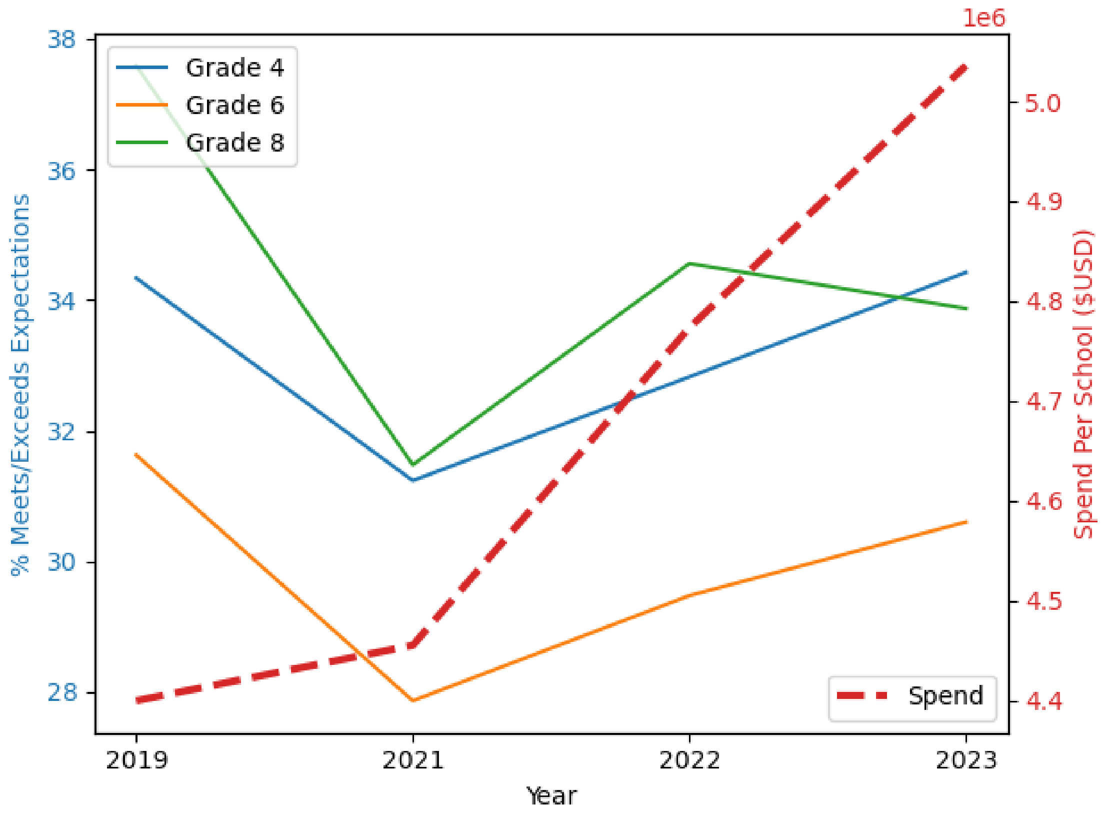


[30]:

```python
## Same plots as above for spend per school
# Generate the average meets/exceeds percentages
def getMeanMeetsOrExceeds(data, grades, years):
    meanMeetsOrExceeds = []
    for year in years:
        for grade in grades:
            # Don't remove 0.0 scores, because some schools actually did report values of 0
            meanMeetsOrExceeds.append(data[(data[year+' Grade '+grade+' meets or exceeds expectations'] != 'N/A')][year+' Grade '+grade+' meets or exceeds expectations'].mean())
    # Order is year, grade as in 2019 - 3, 2019-4, etc
    return meanMeetsOrExceeds

# Remove nans
meanMeetsOrExceeds = np.nan_to_num(np.array(getMeanMeetsOrExceeds(data, grades, years)))

meanMeetsOrExceedsAmended = meanMeetsOrExceeds[1::2]
```

```
## Get the spend per student
def getMeanSpendPerSchool(data, years):
    meanSpendPerSchool = []
    for year in years:
        meanSpendPerSchool.append(data[(data[year+' Total Budget'] != 'N/A') &␣
 ↪(data[year+' Total Budget'] != 0.0)][year+' Total Budget'].mean())
    # Order is year, spendPerStudent
    return meanSpendPerSchool

fig, ax1 = plt.subplots()

print('Grade 4 Percent Change: ', getPercentChange(meanMeetsOrExceedsAmended[0::
 ↪3]))
print('Grade 6 Percent Change: ', getPercentChange(meanMeetsOrExceedsAmended[1::
 ↪3]))
print('Grade 8 Percent Change: ', getPercentChange(meanMeetsOrExceedsAmended[2::
 ↪3]))
print('Total Budget Percent Change: ',␣
 ↪getPercentChange(getMeanSpendPerSchool(data, years)))

color = 'tab:blue'
ax1.set_xlabel('Year')
ax1.set_ylabel('% Meets/Exceeds Expectations', color=color)
ax1.plot(years, meanMeetsOrExceedsAmended[0::3], label="Grade 4")
ax1.plot(years, meanMeetsOrExceedsAmended[1::3], label="Grade 6")
ax1.plot(years, meanMeetsOrExceedsAmended[2::3], label="Grade 8")
ax1.legend(loc="upper left")
ax1.tick_params(axis='y', labelcolor=color)

ax2 = ax1.twinx()  # instantiate a second Axes that shares the same x-axis

color = 'tab:red'
ax2.set_ylabel('Spend Per School ($USD)', color=color)  # we already handled␣
 ↪the x-label with ax1
ax2.plot(years, getMeanSpendPerSchool(data, years), color=color, label="Spend",␣
 ↪linestyle='dashed', linewidth=3.0)
ax2.legend(loc="lower right")
ax2.tick_params(axis='y', labelcolor=color)

fig.tight_layout()  # otherwise the right y-label is slightly clipped
plt.show()
```

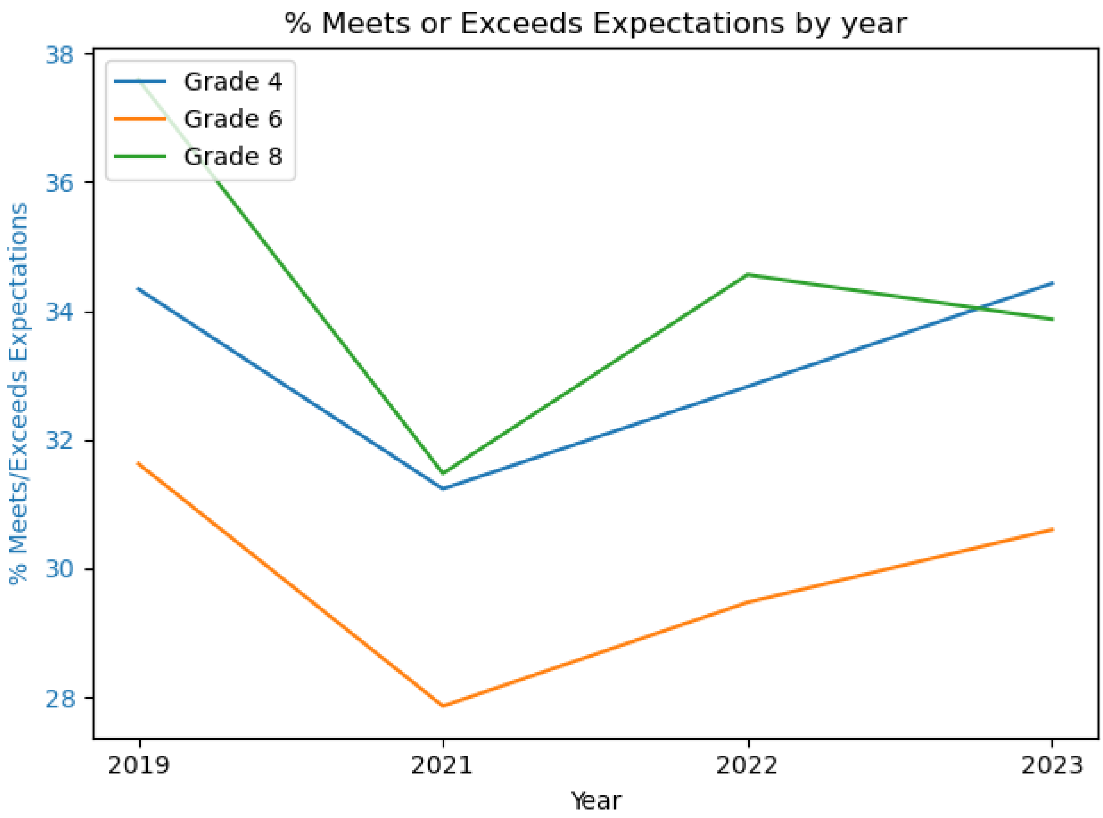
```
Grade 4 Percent Change:  [0, -9.035, 5.086, 4.876]
Grade 6 Percent Change:  [0, -11.899, 5.777, 3.827]
Grade 8 Percent Change:  [0, -16.27, 9.8, -1.995]
Total Budget Percent Change:  [0, 1.262, 7.142, 5.503]
```



```
[53]: ## Same plot as above (performance by year) but also calculates the percent␣
      ↪change
      # Generate the average meets/exceeds percentages
      def getMeanMeetsOrExceeds(data, grades, years):
          meanMeetsOrExceeds = []
          for year in years:
              for grade in grades:
                  # Don't remove 0.0 scores, because some schools actually did report␣
      ↪values of 0
                  meanMeetsOrExceeds.append(data[(data[year+' Grade '+grade+' meets␣
      ↪or exceeds expectations'] != 'N/A')][year+' Grade '+grade+' meets or exceeds␣
      ↪expectations'].mean())
          # Order is year, grade as in 2019 - 3, 2019-4, etc
          return meanMeetsOrExceeds

      # Remove nans
      meanMeetsOrExceeds = np.nan_to_num(np.array(getMeanMeetsOrExceeds(data, grades,␣
      ↪years)))

      meanMeetsOrExceedsAmended = meanMeetsOrExceeds[1::2]
```

```python
## Get the spend per student
def getMeanSpendPerStudent(data, years):
    meanSpendPerStudent = []
    for year in years:
        meanSpendPerStudent.append(data[(data[year+' Spend Per Student'] != 'N/A') & (data[year+' Spend Per Student'] != 0.0)][year+' Spend Per Student'].mean())
    # Order is year, spendPerStudent
    return meanSpendPerStudent

print('Grade 4 Percent Change: ', getPercentChange(meanMeetsOrExceedsAmended[0::3]))
print('Grade 6 Percent Change: ', getPercentChange(meanMeetsOrExceedsAmended[1::3]))
print('Grade 8 Percent Change: ', getPercentChange(meanMeetsOrExceedsAmended[2::3]))
print('Total Budget Percent Change: ', getPercentChange(getMeanSpendPerStudent(data, years)))

fig, ax1 = plt.subplots()

color = 'tab:blue'
ax1.set_xlabel('Year')
ax1.set_ylabel('% Meets/Exceeds Expectations', color=color)
ax1.plot(years, meanMeetsOrExceedsAmended[0::3], label="Grade 4")
ax1.plot(years, meanMeetsOrExceedsAmended[1::3], label="Grade 6")
ax1.plot(years, meanMeetsOrExceedsAmended[2::3], label="Grade 8")
ax1.legend(loc="upper left")
ax1.set_title('% Meets or Exceeds Expectations by year')
ax1.tick_params(axis='y', labelcolor=color)

fig.tight_layout()  # otherwise the right y-label is slightly clipped
plt.show()
```

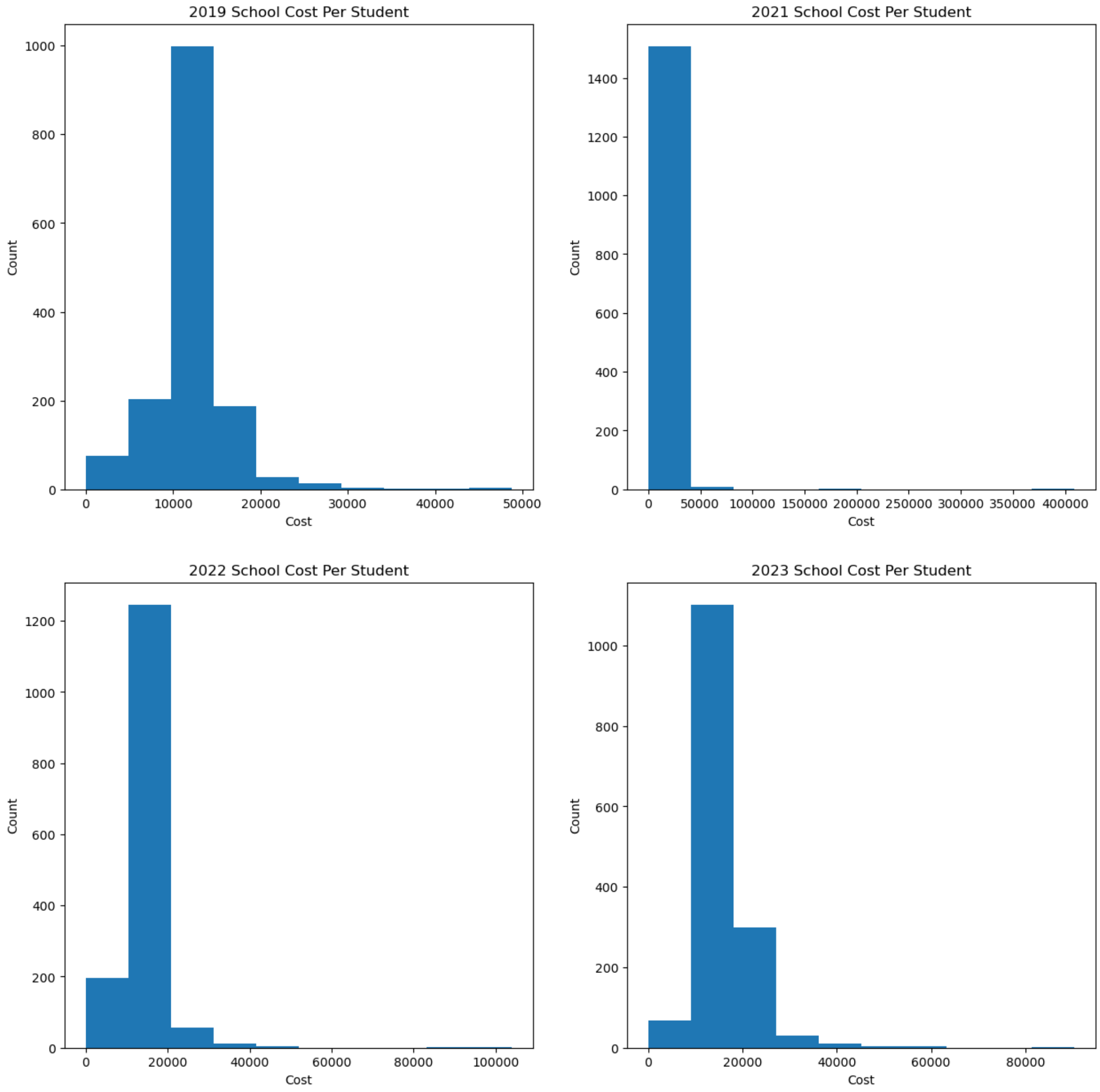
```
Grade 4 Percent Change:  [0, -9.035, 5.086, 4.876]
Grade 6 Percent Change:  [0, -11.899, 5.777, 3.827]
Grade 8 Percent Change:  [0, -16.27, 9.8, -1.995]
Total Budget Percent Change:  [0, 9.766, 6.313, 9.902]
```



[9]:
```
## Now some 10 bin plots of spend per student
spendPerStudent_2019 = data['2019 Spend Per Student']
spendPerStudent_2021 = data['2021 Spend Per Student']
spendPerStudent_2022 = data['2022 Spend Per Student']
spendPerStudent_2023 = data['2023 Spend Per Student']

fig, ((ax1, ax2), (ax3, ax4)) = plt.subplots(2, 2)

fig.set_figheight(15)
fig.set_figwidth(15)

ax1.hist(spendPerStudent_2019, bins=10)
ax1.set_xlabel('Cost')
ax1.set_ylabel('Count')
ax1.set_title('2019 School Cost Per Student')

ax2.hist(spendPerStudent_2021, bins=10)
ax2.set_xlabel('Cost')
ax2.set_ylabel('Count')
ax2.set_title('2021 School Cost Per Student')
```

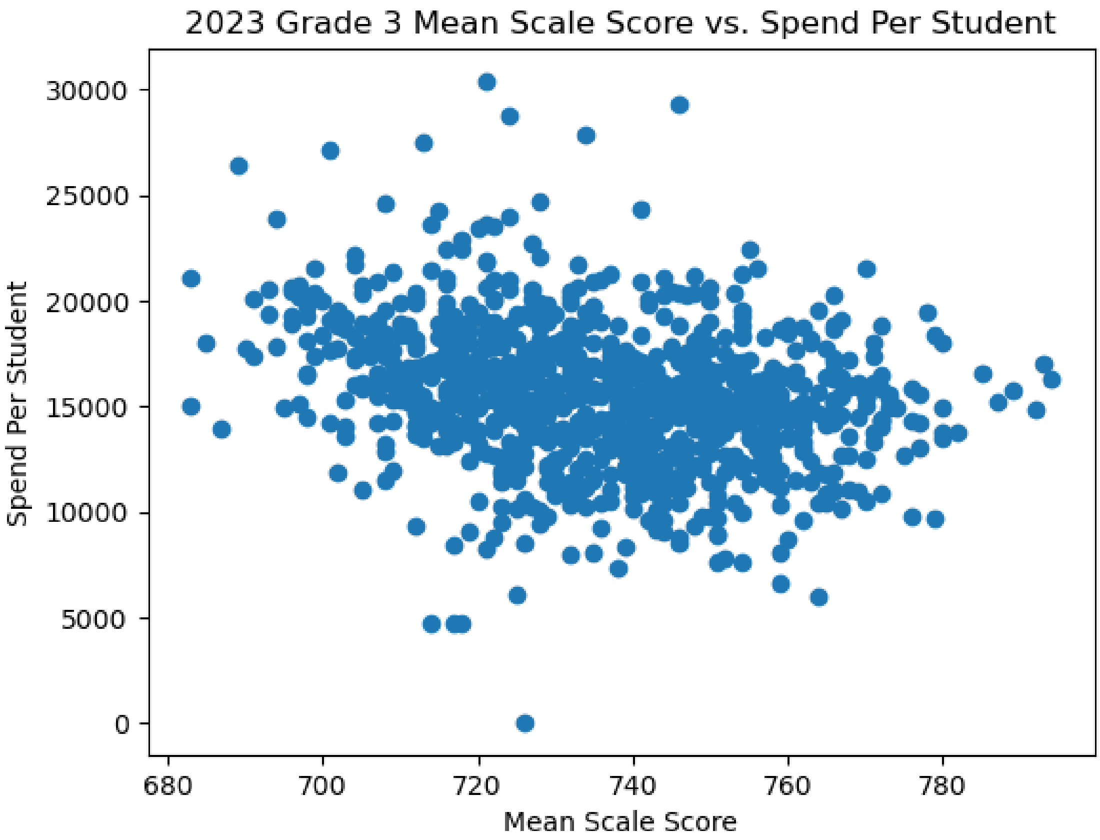
```python
ax3.hist(spendPerStudent_2022, bins=10)
ax3.set_xlabel('Cost')
ax3.set_ylabel('Count')
ax3.set_title('2022 School Cost Per Student')

ax4.hist(spendPerStudent_2023, bins=10)
ax4.set_xlabel('Cost')
ax4.set_ylabel('Count')
ax4.set_title('2023 School Cost Per Student')
print(spendPerStudent_2023.max())
```

```
90435
```



[13]:
```
## Now let's generate a scatterplot, with spending on the x axis, and scores on␣
 ↪the y-axis
scatterplot_2023 = data[(data['2023 Grade 3 Mean Scale Score'].notnull()) &␣
 ↪(data['2023 Grade 3 Mean Scale Score'] != 0.0)]
plt.scatter(scatterplot_2023['2023 Grade 3 Mean Scale Score'],␣
 ↪scatterplot_2023['2023 Spend Per Student'])
# plt.plot(Results_2023['School Code'], met_expect, label="% Met Expectations")
plt.xlabel('Mean Scale Score')
plt.ylabel('Spend Per Student')
plt.title('2023 Grade 3 Mean Scale Score vs. Spend Per Student')
```

[13]:
```
Text(0.5, 1.0, '2023 Grade 3 Mean Scale Score vs. Spend Per Student')
```

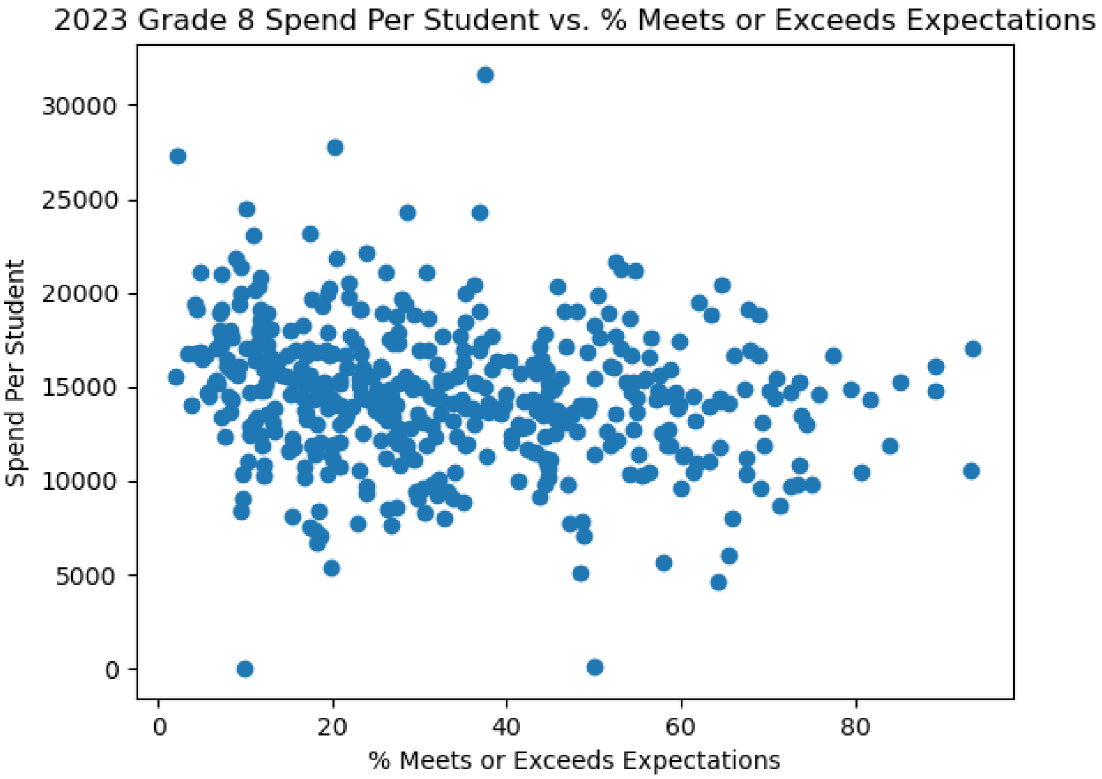


[14]:
```
## Now let's generate a scatterplot, with spending on the x axis, and meets/
 ↪exceeds on the y-axis
scatterplot_2023 = data[(data['2023 Grade 8 Mean Scale Score'].notnull()) &␣
 ↪(data['2023 Grade 8 Mean Scale Score'] != 0.0)]
plt.scatter(scatterplot_2023['2023 Grade 8 meets or exceeds expectations'],␣
 ↪scatterplot_2023['2023 Spend Per Student'])
# plt.plot(Results_2023['School Code'], met_expect, label="% Met Expectations")
```

```
plt.xlabel('% Meets or Exceeds Expectations')
plt.ylabel('Spend Per Student')
plt.title('2023 Grade 8 Spend Per Student vs. % Meets or Exceeds Expectations')
```

[14]:

```
Text(0.5, 1.0, '2023 Grade 8 Spend Per Student vs. % Meets or Exceeds
Expectations')
```



[ ]:

[15]:

```
## Let's look at the 10 largest and 10 smallest cost per student
# largest_ten = data['2023 Spend Per Student'].nlargest(n=10)
# df[df['Ticket'] == 1].sort_values('Age')['Names'].head(10)
smallest_ten = data[(data['2023 Spend Per Student'].notnull()) & (data['2023␣
 ↪Spend Per Student'] != 0)].sort_values('2023 Spend Per Student').head(10)
largest_ten = data.sort_values('2023 Spend Per Student').tail(10)
top_bottom = pd.concat([largest_ten, smallest_ten])
top_bottom.to_csv('big_and_small.csv')
print(largest_ten['2023 Spend Per Student'])
print(top_bottom)
```

```
963     43773
116     43805
```

```
1148    45428
1147    48199
769     49089
265     53225
274     56481
526     59743
266     60635
953     90435
Name: 2023 Spend Per Student, dtype: int64
      Unnamed: 0   Level  District Code                  District Name  \
963        11877  SCHOOL           1420           Jefferson County R-1   
116         3887  SCHOOL            100                 Alamosa RE-11J   
1148       13543  SCHOOL           1760             Kim Reorganized 88   
1147       13535  SCHOOL           1760             Kim Reorganized 88   
769        10077  SCHOOL           1020           Cheyenne Mountain 12   
265         5302  SCHOOL            230                     Walsh RE-1   
274         5371  SCHOOL            270                     Campo RE-6   
526         7784  SCHOOL            880                Denver County 1   
266         5310  SCHOOL            230                     Walsh RE-1   
953        11781  SCHOOL           1420           Jefferson County R-1   
301         5621  SCHOOL            470           St Vrain Valley RE1J   
1036       12523  SCHOOL           1440                 Plainview RE-2   
1318       15038  SCHOOL           2700               Pueblo County 70   
1416       15915  SCHOOL           3100                      Weld RE-4   
1313       14997  SCHOOL           2690                 Pueblo City 60   
1513       16927  SCHOOL           9170   Education reEnvisioned BOCES   
79          3508  SCHOOL             40            School District 27J   
82          3535  SCHOOL             40            School District 27J   
74          3448  SCHOOL             40            School District 27J   
678         9259  SCHOOL            980                     Harrison 2   

      School Code                                       School Name  \
963          5415                        Rocky Mountain Deaf School   
116           270                                    Alamosa Online   
1148         4694                         Kim Undivided High School   
1147         4690                             Kim Elementary School   
769          9804                                      Zebulon Pike   
265          9222                           Walsh Elementary School   
274          1252                       Campo Undivided High School   
526          7163                                      Prep Academy   
266          9226                                 Walsh High School   
953          4798  Connections Learning Center on the Earle Johns…   
301          4333                         Firestone Charter Academy   
1036         6992                       Plainview Elementary School   
1318          856                              Beulah Middle School   
1416         9563             Windsor Charter Academy Middle School   
1313         9808                       Pueblo Youth Service Center   
1513         1007                     Education reEnvisioned School   
```

```
79          5918                    Southlawn Elementary School
82          6687                             27J Online Academy
74          1796                   Colorado Connections Academy
678         5898             Atlas Preparatory Elementary School

          Content       Grade Number of Total Records Number of Valid Scores  \
963   Mathematics  All Grades                        32                     29
116   Mathematics  All Grades                         6                   < 16
1148  Mathematics  All Grades                         7                   < 16
1147  Mathematics  All Grades                       < 4                    - -
769   Mathematics  All Grades                       < 4                    - -
265   Mathematics  All Grades                        64                     58
274   Mathematics  All Grades                         4                   < 16
526   Mathematics  All Grades                        15                   < 16
266   Mathematics  All Grades                        28                     26
953   Mathematics  All Grades                        26                     20
301   Mathematics  All Grades                       347                    326
1036  Mathematics  All Grades                         5                   < 16
1318  Mathematics  All Grades                        42                     40
1416  Mathematics  All Grades                       370                    355
1313  Mathematics  All Grades                       < 4                    - -
1513  Mathematics  All Grades                        12                   < 16
79    Mathematics  All Grades                       194                    188
82    Mathematics  All Grades                       148                     29
74    Mathematics  All Grades                       652                    190
678   Mathematics  All Grades                       100                    100

      … 2021 Grade 7 Mean Scale Score 2019 Grade 7 Mean Scale Score  \
963   …                           NaN                           NaN
116   …                           NaN                           NaN
1148  …                           NaN                           NaN
1147  …                           NaN                           NaN
769   …                           NaN                           NaN
265   …                           NaN                           NaN
274   …                           NaN                           NaN
526   …                           NaN                           NaN
266   …                           NaN                           NaN
953   …                           NaN                         697.0
301   …                           NaN                         743.0
1036  …                           NaN                           NaN
1318  …                           NaN                         733.0
1416  …                           NaN                           NaN
1313  …                           NaN                           NaN
1513  …                           NaN                           NaN
79    …                           NaN                           NaN
82    …                           NaN                           NaN
74    …                           NaN                           NaN
678   …                           NaN                           NaN
```

```
     2023 Grade 8 meets or exceeds expectations  \
963                                         NaN   
116                                         NaN   
1148                                        NaN   
1147                                        NaN   
769                                         NaN   
265                                         NaN   
274                                         NaN   
526                                         NaN   
266                                         NaN   
953                                         NaN   
301                                        50.0   
1036                                        NaN   
1318                                        NaN   
1416                                       64.2   
1313                                        NaN   
1513                                        NaN   
79                                          NaN   
82                                          NaN   
74                                          NaN   
678                                         NaN   

     2022 Grade 8 meets or exceeds expectations  \
963                                         NaN   
116                                         NaN   
1148                                        NaN   
1147                                        NaN   
769                                         NaN   
265                                         NaN   
274                                         NaN   
526                                         NaN   
266                                         NaN   
953                                         NaN   
301                                        41.2   
1036                                        NaN   
1318                                        NaN   
1416                                       71.1   
1313                                        NaN   
1513                                        NaN   
79                                          NaN   
82                                          NaN   
74                                          NaN   
678                                         NaN   

     2021 Grade 8 meets or exceeds expectations  \
963                                         NaN   
116                                         NaN   
```

```
1148                                        NaN
1147                                        NaN
769                                         NaN
265                                         NaN
274                                         NaN
526                                         NaN
266                                         NaN
953                                         NaN
301                                        20.6
1036                                        NaN
1318                                        NaN
1416                                       41.7
1313                                        NaN
1513                                        NaN
79                                          NaN
82                                          NaN
74                                          NaN
678                                         NaN

     2019 Grade 8 meets or exceeds expectations 2023 Grade 8 Mean Scale Score  \
963                                         NaN                           NaN
116                                         NaN                           NaN
1148                                        NaN                           NaN
1147                                        NaN                           NaN
769                                         NaN                           NaN
265                                         NaN                           NaN
274                                         NaN                           NaN
526                                         NaN                           NaN
266                                         NaN                           NaN
953                                         NaN                           NaN
301                                        51.1                         747.0
1036                                        NaN                           NaN
1318                                        NaN                         725.0
1416                                        NaN                         763.0
1313                                        NaN                           NaN
1513                                        NaN                           NaN
79                                          NaN                           NaN
82                                          NaN                           NaN
74                                          NaN                         721.0
678                                         NaN                           NaN

     2022 Grade 8 Mean Scale Score 2021 Grade 8 Mean Scale Score  \
963                            NaN                           NaN
116                            NaN                           NaN
1148                           NaN                           NaN
1147                           NaN                           NaN
769                            NaN                           NaN
265                            NaN                           NaN
```

```
274                            NaN                           NaN
526                            NaN                           NaN
266                            NaN                           NaN
953                            NaN                           NaN
301                          734.0                         725.0
1036                           NaN                           NaN
1318                         719.0                           NaN
1416                         763.0                         745.0
1313                           NaN                           NaN
1513                           NaN                           NaN
79                             NaN                           NaN
82                             NaN                           NaN
74                             NaN                           NaN
678                            NaN                           NaN

     2019 Grade 8 Mean Scale Score
963                            NaN
116                            NaN
1148                           NaN
1147                           NaN
769                            NaN
265                            NaN
274                            NaN
526                            NaN
266                            NaN
953                          676.0
301                          745.0
1036                           NaN
1318                         741.0
1416                           NaN
1313                           NaN
1513                           NaN
79                             NaN
82                             NaN
74                             NaN
678                            NaN

[20 rows x 88 columns]
```