In [33]:
```python
#There isnt enough data
import numpy as np
import pandas as pd

stand_test = pd.read_csv(r"C:\Users\djbro\OneDrive\Desktop\Multiple Linear Regression\Te
stand_test1= pd.read_csv(r"C:\Users\djbro\OneDrive\Desktop\Multiple Linear Regression\Te
```

In [34]:
```python
#Concatenate wine and wine1
a=[stand_test,stand_test1]
dataset = pd.concat(a)
dataset
```

Out[34]:

	grade	male	raceeth	preschool	expectBachelors	motherHS	motherBachelors	motherWork	fatherHS	fa
0	10	0	White	1.0	0.0	1.0	1.0	1.0	1.0	
1	10	1	White	0.0	0.0	1.0	0.0	1.0	1.0	
2	10	0	White	1.0	0.0	1.0	0.0	1.0	1.0	
3	10	0	White	1.0	0.0	1.0	1.0	1.0	1.0	
4	10	0	White	1.0	1.0	1.0	0.0	0.0	1.0	
...	...	...	...	...	...	...	...	...	...	
3658	9	1	White	0.0	1.0	1.0	NaN	0.0	1.0	
3659	9	1	White	0.0	0.0	1.0	0.0	1.0	1.0	
3660	10	1	Hispanic	1.0	1.0	1.0	0.0	1.0	1.0	
3661	11	1	Black	0.0	0.0	1.0	0.0	NaN	NaN	
3662	10	0	White	0.0	1.0	1.0	0.0	1.0	1.0	

5233 rows × 24 columns

In [35]:
```python
#Checking for missing values
dataset.isnull().sum()
```

Out[35]:
```
grade                       0
male                        0
raceeth                    48
preschool                  77
expectBachelors            85
motherHS                  142
motherBachelors           585
motherWork                129
fatherHS                  370
fatherBachelors           857
fatherWork                346
selfBornUS                 93
motherBornUS               94
fatherBornUS              171
englishAtHome              98
computerForSchoolwork      95
read30MinsADay             55
minutesPerWeekEnglish     289
studentsInEnglish         363
schoolHasLibrary          201
publicSchool                0
urban                       0
schoolSize                231
```

```
readingScore            0
dtype: int64
```

In [36]:
```python
dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 5233 entries, 0 to 3662
Data columns (total 24 columns):
 #   Column                 Non-Null Count  Dtype
---  ------                 --------------  -----
 0   grade                  5233 non-null   int64
 1   male                   5233 non-null   int64
 2   raceeth                5185 non-null   object
 3   preschool              5156 non-null   float64
 4   expectBachelors        5148 non-null   float64
 5   motherHS               5091 non-null   float64
 6   motherBachelors        4648 non-null   float64
 7   motherWork             5104 non-null   float64
 8   fatherHS               4863 non-null   float64
 9   fatherBachelors        4376 non-null   float64
 10  fatherWork             4887 non-null   float64
 11  selfBornUS             5140 non-null   float64
 12  motherBornUS           5139 non-null   float64
 13  fatherBornUS           5062 non-null   float64
 14  englishAtHome          5135 non-null   float64
 15  computerForSchoolwork  5138 non-null   float64
 16  read30MinsADay         5178 non-null   float64
 17  minutesPerWeekEnglish  4944 non-null   float64
 18  studentsInEnglish      4870 non-null   float64
 19  schoolHasLibrary       5032 non-null   float64
 20  publicSchool           5233 non-null   int64
 21  urban                  5233 non-null   int64
 22  schoolSize             5002 non-null   float64
 23  readingScore           5233 non-null   float64
dtypes: float64(19), int64(4), object(1)
memory usage: 1022.1+ KB
```

In [37]:
```python
dataset = dataset.dropna()
```

In [38]:
```python
#Checking for missing values
dataset.isnull().sum()
```

Out[38]:
```
grade                    0
male                     0
raceeth                  0
preschool                0
expectBachelors          0
motherHS                 0
motherBachelors          0
motherWork               0
fatherHS                 0
fatherBachelors          0
fatherWork               0
selfBornUS               0
motherBornUS             0
fatherBornUS             0
englishAtHome            0
computerForSchoolwork    0
read30MinsADay           0
minutesPerWeekEnglish    0
studentsInEnglish        0
schoolHasLibrary         0
publicSchool             0
urban                    0
schoolSize               0
```

```
readingScore             0
dtype: int64
```

In [39]:

```
#Import label encoder
from sklearn import preprocessing

#label_encoder object knows how to understand word labels
label_encoder = preprocessing.LabelEncoder()

#Encode labels in column Sex and Embarked
dataset['raceeth']= label_encoder.fit_transform(dataset['raceeth'])
```

```
C:\Users\djbro\AppData\Local\Temp\ipykernel_14736\2164675448.py:8: SettingWithCopyWarnin
g:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_
guide/indexing.html#returning-a-view-versus-a-copy
  dataset['raceeth']= label_encoder.fit_transform(dataset['raceeth'])
```

In [40]:

```
# Checking for null values
print(dataset.info())

# Checking for outliers
print(dataset.describe())
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 3404 entries, 0 to 3662
Data columns (total 24 columns):
 #   Column                 Non-Null Count  Dtype  
---  ------                 --------------  -----  
 0   grade                  3404 non-null   int64  
 1   male                   3404 non-null   int64  
 2   raceeth                3404 non-null   int32  
 3   preschool              3404 non-null   float64
 4   expectBachelors        3404 non-null   float64
 5   motherHS               3404 non-null   float64
 6   motherBachelors        3404 non-null   float64
 7   motherWork             3404 non-null   float64
 8   fatherHS               3404 non-null   float64
 9   fatherBachelors        3404 non-null   float64
 10  fatherWork             3404 non-null   float64
 11  selfBornUS             3404 non-null   float64
 12  motherBornUS           3404 non-null   float64
 13  fatherBornUS           3404 non-null   float64
 14  englishAtHome          3404 non-null   float64
 15  computerForSchoolwork  3404 non-null   float64
 16  read30MinsADay         3404 non-null   float64
 17  minutesPerWeekEnglish  3404 non-null   float64
 18  studentsInEnglish      3404 non-null   float64
 19  schoolHasLibrary       3404 non-null   float64
 20  publicSchool           3404 non-null   int64  
 21  urban                  3404 non-null   int64  
 22  schoolSize             3404 non-null   float64
 23  readingScore           3404 non-null   float64
dtypes: float64(19), int32(1), int64(4)
memory usage: 651.5 KB
None
             grade         male      raceeth    preschool  expectBachelors  \
count  3404.000000  3404.000000  3404.000000  3404.000000      3404.000000   
mean     10.126910     0.498531     4.685370     0.725911         0.827556   
std       0.520284     0.500071     1.751875     0.446120         0.377822   
min       8.000000     0.000000     0.000000     0.000000         0.000000   
25%      10.000000     0.000000     3.000000     0.000000         1.000000   
50%      10.000000     0.000000     6.000000     1.000000         1.000000   
```

```
75%      10.000000      1.000000      6.000000      1.000000          1.000000
max      12.000000      1.000000      6.000000      1.000000          1.000000

           motherHS  motherBachelors   motherWork     fatherHS  \
count  3404.000000      3404.000000  3404.000000  3404.000000
mean      0.889542         0.354289     0.730905     0.867215
std       0.313506         0.478368     0.443555     0.339392
min       0.000000         0.000000     0.000000     0.000000
25%       1.000000         0.000000     0.000000     1.000000
50%       1.000000         0.000000     1.000000     1.000000
75%       1.000000         1.000000     1.000000     1.000000
max       1.000000         1.000000     1.000000     1.000000

       fatherBachelors  ...  englishAtHome  computerForSchoolwork  \
count      3404.000000  ...    3404.000000            3404.000000
mean          0.341069  ...       0.876616               0.917156
std           0.474138  ...       0.328926               0.275686
min           0.000000  ...       0.000000               0.000000
25%           0.000000  ...       1.000000               1.000000
50%           0.000000  ...       1.000000               1.000000
75%           1.000000  ...       1.000000               1.000000
max           1.000000  ...       1.000000               1.000000

       read30MinsADay  minutesPerWeekEnglish  studentsInEnglish  \
count     3404.000000            3404.000000        3404.000000
mean         0.299941             269.029377          24.591951
std          0.458299             141.631752           6.966783
min          0.000000               0.000000           1.000000
25%          0.000000             225.000000          20.000000
50%          0.000000             250.000000          25.000000
75%          1.000000             300.000000          30.000000
max          1.000000            2025.000000          90.000000

       schoolHasLibrary  publicSchool        urban   schoolSize  readingScore
count       3404.000000   3404.000000  3404.000000  3404.000000   3404.000000
mean           0.969741      0.916275     0.360165  1372.634841    518.515875
std            0.171323      0.277016     0.480118   855.541812     89.164390
min            0.000000      0.000000     0.000000   100.000000    242.640000
25%            1.000000      1.000000     0.000000   690.000000    457.120000
50%            1.000000      1.000000     0.000000  1233.000000    520.205000
75%            1.000000      1.000000     1.000000  1900.000000    581.980000
max            1.000000      1.000000     1.000000  6694.000000    772.460000

[8 rows x 24 columns]
```

In [41]:
```python
dataset.raceeth.unique()
```

Out[41]:
```
array([6, 0, 3, 2, 4, 1, 5])
```

In [42]:
```python
dataset.head(5)
```

Out[42]:

	grade	male	raceeth	preschool	expectBachelors	motherHS	motherBachelors	motherWork	fatherHS	fathe
0	10	0	6	1.0	0.0	1.0	1.0	1.0	1.0	
4	10	0	6	1.0	1.0	1.0	0.0	0.0	1.0	
6	10	0	0	1.0	0.0	1.0	0.0	0.0	1.0	
7	10	0	6	1.0	0.0	1.0	0.0	1.0	1.0	
8	11	0	6	0.0	0.0	1.0	1.0	1.0	1.0	

5 rows × 24 columns

In [43]:
```python
dataset.columns
```

Out[43]:
```
Index(['grade', 'male', 'raceeth', 'preschool', 'expectBachelors', 'motherHS',
       'motherBachelors', 'motherWork', 'fatherHS', 'fatherBachelors',
       'fatherWork', 'selfBornUS', 'motherBornUS', 'fatherBornUS',
       'englishAtHome', 'computerForSchoolwork', 'read30MinsADay',
       'minutesPerWeekEnglish', 'studentsInEnglish', 'schoolHasLibrary',
       'publicSchool', 'urban', 'schoolSize', 'readingScore'],
      dtype='object')
```

In [44]:
```python
dataset.corr()
```

Out[44]:

	grade	male	raceeth	preschool	expectBachelors	motherHS	motherBachelors
grade	1.000000	-0.088510	-0.023883	0.008111	0.115848	0.015706	0.035358
male	-0.088510	1.000000	0.020437	0.012026	-0.092327	0.030829	0.052541
raceeth	-0.023883	0.020437	1.000000	0.058449	0.033880	0.227232	0.159000
preschool	0.008111	0.012026	0.058449	1.000000	0.103052	0.138550	0.167373
expectBachelors	0.115848	-0.092327	0.033880	0.103052	1.000000	0.119481	0.177169
motherHS	0.015706	0.030829	0.227232	0.138550	0.119481	1.000000	0.243386
motherBachelors	0.035358	0.052541	0.159000	0.167373	0.177169	0.243386	1.000000
motherWork	0.032151	-0.015031	0.069507	0.083065	0.071965	0.160225	0.132301
fatherHS	0.055522	0.028285	0.229714	0.134133	0.160543	0.511132	0.202969
fatherBachelors	0.057963	0.058505	0.170622	0.161456	0.220153	0.229800	0.550203
fatherWork	0.016955	0.039694	0.096688	0.059649	0.033112	0.004112	0.076205
selfBornUS	-0.028336	0.026843	0.244736	0.089791	-0.003177	0.204745	0.034493
motherBornUS	-0.073732	0.000600	0.497586	0.093709	-0.001411	0.375398	0.133455
fatherBornUS	-0.069322	0.011960	0.482441	0.093035	-0.011533	0.346970	0.108897
englishAtHome	-0.009784	-0.006462	0.390556	0.119919	0.051012	0.403534	0.158373
computerForSchoolwork	0.083564	-0.017935	0.086566	0.116375	0.153392	0.162692	0.137949
read30MinsADay	0.041193	-0.200024	-0.008331	-0.013158	0.113816	0.011817	0.029851
minutesPerWeekEnglish	0.038795	-0.004372	0.017388	-0.019020	0.012247	0.009788	0.015066
studentsInEnglish	0.054908	-0.036653	-0.070715	-0.030417	0.032652	-0.044187	-0.041785
schoolHasLibrary	-0.026137	0.032066	-0.011168	0.006801	0.032860	0.008879	-0.005408
publicSchool	-0.048588	-0.088922	-0.048847	-0.100144	-0.109911	-0.076067	-0.186335
urban	0.080475	0.025459	-0.285179	-0.015045	0.024974	-0.108504	-0.023489
schoolSize	0.068044	-0.003000	-0.197085	-0.012268	0.038534	-0.081655	-0.003737
readingScore	0.222190	-0.120640	0.247034	0.075072	0.343326	0.152614	0.228640

24 rows × 24 columns

In [45]:
```python
from sklearn.model_selection import train_test_split

# We specify random seed so that the train and test data set always have the same rows,
np.random.seed(0)
df_train, df_test = train_test_split(dataset, train_size = 0.7, test_size = 0.3, random_
```

In [46]:
```
#Re-scaling the Features
#We can see that all the columns have
#smaller integer values in the dataset
#except the area column. So it is important to
#re-scale the variables so that they all have a comparable scale.
#If we don't have relative scales, then some of the regression model
#coefficients will be of different units compared to the other coefficients.

#To do that, we use the MinMax scaling method.
```

In [47]:
```
from sklearn.preprocessing import MinMaxScaler
scaler = MinMaxScaler()

#Applying scaler() to all the columns except the 'yes-no' and 'dummy' variables
num_vars = ['minutesPerWeekEnglish', 'studentsInEnglish', 'schoolSize', 'readingScore','
df_train[num_vars] = scaler.fit_transform(df_train[num_vars])

df_train
```

Out[47]:

	grade	male	raceeth	preschool	expectBachelors	motherHS	motherBachelors	motherWork	fatherHS	f
1938	0.50	1	0.333333	1.0	1.0	1.0	0.0	1.0	1.0	
611	0.25	0	1.000000	0.0	1.0	0.0	1.0	0.0	1.0	
48	0.50	0	0.166667	1.0	1.0	1.0	0.0	1.0	1.0	
1169	0.50	1	0.333333	1.0	1.0	1.0	1.0	1.0	1.0	
745	0.50	1	1.000000	1.0	1.0	1.0	0.0	1.0	1.0	
...	...	...	...	...	...	...	...	...	...	
1309	0.75	0	0.333333	0.0	1.0	0.0	0.0	0.0	1.0	
3439	0.25	1	0.500000	1.0	1.0	1.0	0.0	1.0	1.0	
1017	0.50	0	0.500000	1.0	1.0	0.0	0.0	0.0	0.0	
2450	0.50	1	1.000000	1.0	1.0	1.0	1.0	1.0	1.0	
2631	0.50	1	0.666667	1.0	0.0	1.0	1.0	1.0	1.0	

2382 rows × 24 columns

In [48]:
```
# Dividing the training data set into X and Y
y_train = df_train.pop('readingScore')
X_train = df_train
```

In [49]:
```
#Build a linear model

import statsmodels.api as sm
X_train_lm = sm.add_constant(X_train)

lr_1 = sm.OLS(y_train, X_train_lm).fit()

lr_1.summary()
```

Out[49]:

OLS Regression Results

Dep. Variable:	readingScore	**R-squared:**	0.290
Model:	OLS	**Adj. R-squared:**	0.283
Method:	Least Squares	**F-statistic:**	41.94
Date:	Sat, 24 Dec 2022	**Prob (F-statistic):**	9.41e-157

Time:	13:49:20	**Log-Likelihood:**	1276.6
No. Observations:	2382	**AIC:**	-2505.
Df Residuals:	2358	**BIC:**	-2367.
Df Model:	23		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.1484	0.032	4.575	0.000	0.085	0.212
grade	0.2120	0.023	9.146	0.000	0.167	0.257
male	-0.0206	0.006	-3.416	0.001	-0.032	-0.009
raceeth	0.1335	0.012	10.883	0.000	0.109	0.158
preschool	-0.0009	0.007	-0.136	0.892	-0.014	0.012
expectBachelors	0.0954	0.008	11.520	0.000	0.079	0.112
motherHS	0.0103	0.012	0.873	0.383	-0.013	0.034
motherBachelors	0.0213	0.008	2.820	0.005	0.006	0.036
motherWork	0.0009	0.007	0.126	0.900	-0.013	0.014
fatherHS	0.0213	0.011	1.998	0.046	0.000	0.042
fatherBachelors	0.0427	0.008	5.519	0.000	0.028	0.058
fatherWork	0.0044	0.008	0.517	0.605	-0.012	0.021
selfBornUS	-0.0001	0.013	-0.008	0.994	-0.026	0.026
motherBornUS	-0.0328	0.013	-2.595	0.010	-0.058	-0.008
fatherBornUS	0.0110	0.012	0.903	0.366	-0.013	0.035
englishAtHome	0.0076	0.013	0.580	0.562	-0.018	0.033
computerForSchoolwork	0.0353	0.011	3.198	0.001	0.014	0.057
read30MinsADay	0.0643	0.007	9.781	0.000	0.051	0.077
minutesPerWeekEnglish	0.0443	0.036	1.229	0.219	-0.026	0.115
studentsInEnglish	-0.0050	0.034	-0.148	0.882	-0.072	0.062
schoolHasLibrary	0.0047	0.017	0.278	0.781	-0.028	0.038
publicSchool	-0.0369	0.013	-2.918	0.004	-0.062	-0.012
urban	-2.712e-05	0.008	-0.003	0.997	-0.015	0.015
schoolSize	0.0787	0.028	2.802	0.005	0.024	0.134

Omnibus:	2.001	**Durbin-Watson:**	1.989
Prob(Omnibus):	0.368	**Jarque-Bera (JB):**	1.934
Skew:	-0.067	**Prob(JB):**	0.380
Kurtosis:	3.041	**Cond. No.**	47.3

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

In [50]:
```
#Recursive Feature Elimination (RFE)
#RFE is an automatic process where we don’t need to select
#variables manually. We follow the same steps we have done earlier
#until Re-scaling the features and dividing the data into X and Y.

#We will use the LinearRegression function from sklearn
#for RFE (which is a utility from sklearn)
```

In [51]:
```
# Importing RFE and LinearRegression
from sklearn.feature_selection import RFE
from sklearn.linear_model import LinearRegression
```

In [52]:
```
# Running RFE with the output number of the variable equal to 10
lm = LinearRegression()
lm.fit(X_train, y_train)

rfe = RFE(lm,n_features_to_select=10)             # running RFE
rfe = rfe.fit(X_train, y_train)

list(zip(X_train.columns,rfe.support_,rfe.ranking_))
```

Out[52]:
```
[('grade', True, 1),
 ('male', False, 3),
 ('raceeth', True, 1),
 ('preschool', False, 11),
 ('expectBachelors', True, 1),
 ('motherHS', False, 6),
 ('motherBachelors', False, 2),
 ('motherWork', False, 12),
 ('fatherHS', True, 1),
 ('fatherBachelors', True, 1),
 ('fatherWork', False, 10),
 ('selfBornUS', False, 13),
 ('motherBornUS', False, 4),
 ('fatherBornUS', False, 5),
 ('englishAtHome', False, 7),
 ('computerForSchoolwork', True, 1),
 ('read30MinsADay', True, 1),
 ('minutesPerWeekEnglish', True, 1),
 ('studentsInEnglish', False, 8),
 ('schoolHasLibrary', False, 9),
 ('publicSchool', True, 1),
 ('urban', False, 14),
 ('schoolSize', True, 1)]
```

In [53]:
```
# Creating X_test dataframe with RFE selected variables
col = ['grade','raceeth','expectBachelors','motherBachelors','fatherHS','fatherBachelors
X_train_rfe = X_train[col]

# Adding a constant variable
import statsmodels.api as sm
X_train_rfe = sm.add_constant(X_train_rfe)

lm = sm.OLS(y_train,X_train_rfe).fit()    # Running the linear model

print(lm.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:           readingScore   R-squared:                       0.283
Model:                            OLS   Adj. R-squared:                  0.280
Method:                 Least Squares   F-statistic:                     93.63
```

```
Date:                  Sat, 24 Dec 2022   Prob (F-statistic):          2.41e-163
Time:                          13:49:20   Log-Likelihood:                 1264.5
No. Observations:                  2382   AIC:                            -2507.
Df Residuals:                      2371   BIC:                            -2444.
Df Model:                            10
Covariance Type:              nonrobust
==========================================================================================
=
                             coef    std err          t      P>|t|      [0.025      0.97
5]
------------------------------------------------------------------------------------------
-
const                      0.1532      0.021      7.250      0.000       0.112       0.19
5
grade                      0.2231      0.023      9.710      0.000       0.178       0.26
8
raceeth                    0.1329      0.012     11.221      0.000       0.110       0.15
6
expectBachelors            0.0995      0.008     12.110      0.000       0.083       0.11
6
motherBachelors            0.0220      0.007      2.967      0.003       0.007       0.03
7
fatherHS                   0.0260      0.010      2.705      0.007       0.007       0.04
5
fatherBachelors            0.0433      0.008      5.627      0.000       0.028       0.05
8
motherBornUS              -0.0237      0.009     -2.743      0.006      -0.041      -0.00
7
computerForSchoolwork      0.0390      0.011      3.571      0.000       0.018       0.06
0
read30MinsADay             0.0680      0.006     10.551      0.000       0.055       0.08
1
publicSchool              -0.0226      0.010     -2.165      0.030      -0.043      -0.00
2
==============================================================================
Omnibus:                        1.921   Durbin-Watson:                   1.988
Prob(Omnibus):                  0.383   Jarque-Bera (JB):                1.844
Skew:                          -0.063   Prob(JB):                        0.398
Kurtosis:                       3.052   Cond. No.                         23.4
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specifi
ed.
```

In [54]:

```python
from statsmodels.stats.outliers_influence import variance_inflation_factor
vif = pd.DataFrame()
X = X_train_rfe
vif['Features'] = X.columns
vif['VIF'] = [variance_inflation_factor(X.values, i) for i in range(X.shape[1])]
print(vif)
```

```
                 Features        VIF
0                   const  52.263214
1                   grade   1.027453
2                 raceeth   1.383522
3         expectBachelors   1.116988
4         motherBachelors   1.478825
5                fatherHS   1.260773
6         fatherBachelors   1.557503
7            motherBornUS   1.484564
8   computerForSchoolwork   1.071096
9          read30MinsADay   1.018813
10           publicSchool   1.060722
```

In [55]:

```python
X_train_new = X_train_rfe.drop(["const"], axis = 1)
```

```
# Adding a constant variable
import statsmodels.api as sm
X_train_lm = sm.add_constant(X_train_new)

lm = sm.OLS(y_train,X_train_lm).fit()   # Running the linear model
print(lm.summary())

vif = pd.DataFrame()
X = X_train_new
vif['Features'] = X.columns
vif['VIF'] = [variance_inflation_factor(X.values, i) for i in range(X.shape[1])]
print(vif)
```

```
                            OLS Regression Results                            
==============================================================================
Dep. Variable:           readingScore   R-squared:                       0.283
Model:                            OLS   Adj. R-squared:                  0.280
Method:                 Least Squares   F-statistic:                     93.63
Date:                Sat, 24 Dec 2022   Prob (F-statistic):          2.41e-163
Time:                        13:49:20   Log-Likelihood:                 1264.5
No. Observations:                2382   AIC:                            -2507.
Df Residuals:                    2371   BIC:                            -2444.
Df Model:                          10                                         
Covariance Type:            nonrobust                                         
==========================================================================================
=
                             coef    std err          t      P>|t|      [0.025      0.97
5]
------------------------------------------------------------------------------------------
-
const                      0.1532      0.021      7.250      0.000       0.112       0.19
5
grade                      0.2231      0.023      9.710      0.000       0.178       0.26
8
raceeth                    0.1329      0.012     11.221      0.000       0.110       0.15
6
expectBachelors            0.0995      0.008     12.110      0.000       0.083       0.11
6
motherBachelors            0.0220      0.007      2.967      0.003       0.007       0.03
7
fatherHS                   0.0260      0.010      2.705      0.007       0.007       0.04
5
fatherBachelors            0.0433      0.008      5.627      0.000       0.028       0.05
8
motherBornUS              -0.0237      0.009     -2.743      0.006      -0.041      -0.00
7
computerForSchoolwork      0.0390      0.011      3.571      0.000       0.018       0.06
0
read30MinsADay             0.0680      0.006     10.551      0.000       0.055       0.08
1
publicSchool              -0.0226      0.010     -2.165      0.030      -0.043      -0.00
2
==============================================================================
Omnibus:                        1.921   Durbin-Watson:                   1.988
Prob(Omnibus):                  0.383   Jarque-Bera (JB):                1.844
Skew:                          -0.063   Prob(JB):                        0.398
Kurtosis:                       3.052   Cond. No.                         23.4
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specifi
ed.
                Features        VIF
0                  grade  13.334303
1                raceeth  10.784652
```

```
2          expectBachelors   6.273012
3          motherBachelors   2.295383
4                 fatherHS   9.107929
5          fatherBachelors   2.357636
6             motherBornUS   6.824334
7   computerForSchoolwork  11.198686
8            read30MinsADay   1.448749
9             publicSchool   8.536986
```

In [56]:
```
#Since the p-values and VIF are in the desired range, we'll move forward with the analys
```

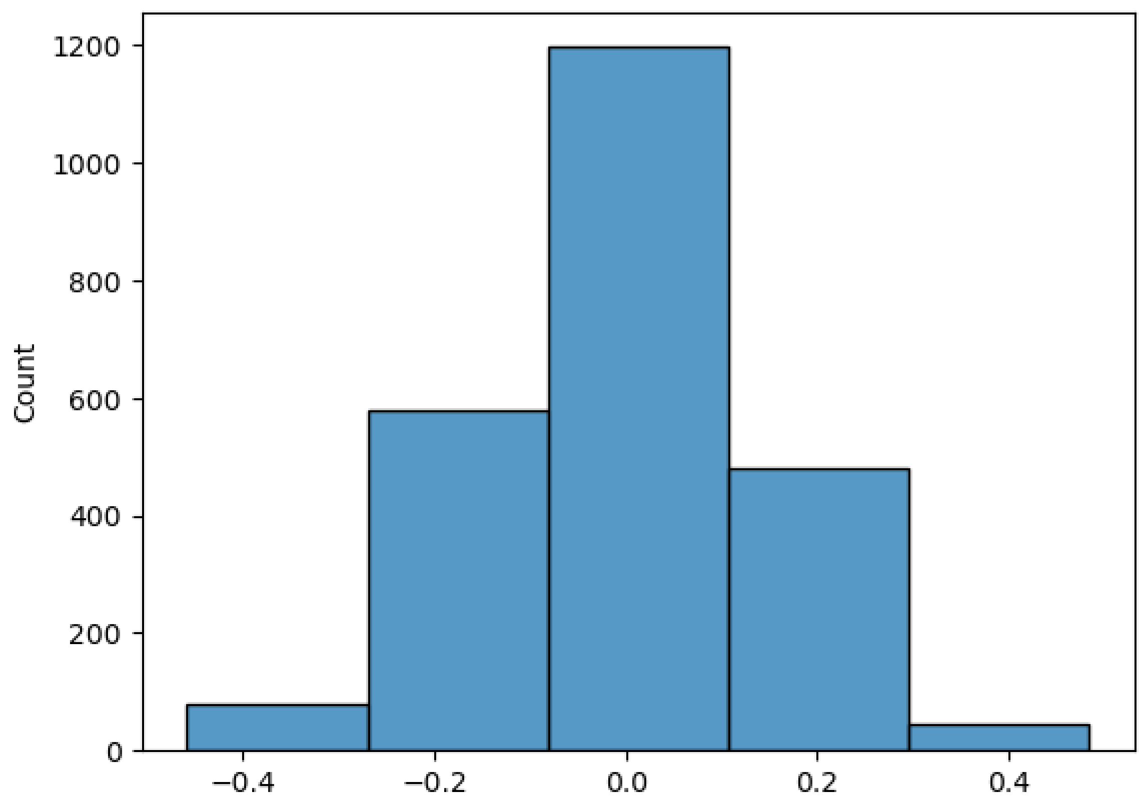
In [57]:
```
#The next step is the residual analysis of error terms.

#Residual Analysis
#So, let's check if the error terms are also normally distributed using a histogram.
```

In [58]:
```
y_train_price = lm.predict(X_train_lm)
# Importing the required libraries for plots.
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline

# Plot the histogram of the error terms
fig = plt.figure()
sns.histplot((y_train - y_train_price), bins = 5)
```

Out[58]:
```
<AxesSubplot:ylabel='Count'>
```



In [59]:
```
num_vars = ['minutesPerWeekEnglish', 'studentsInEnglish', 'schoolSize', 'readingScore','
df_test[num_vars] = scaler.transform(df_test[num_vars])

y_test = df_test.pop('readingScore')
X_test = df_test

# Now let's use our model to make predictions.

# Creating X_test_new dataframe by dropping variables from X_test
X_test_new = X_test[X_train_new.columns]
```

```python
# Adding a constant variable
X_test_new = sm.add_constant(X_test_new)

# Making predictions
y_pred = lm.predict(X_test_new)
```

In [60]:
```python
from sklearn.metrics import r2_score
r2_score(y_true = y_test, y_pred = y_pred)
```

Out[60]:
```
0.2823514158060685
```

In [61]:
```python
from sklearn import metrics
print(metrics.mean_absolute_error(y_test, y_pred))
print(metrics.mean_squared_error(y_test, y_pred))
print(np.sqrt(metrics.mean_squared_error(y_test, y_pred)))
```

```
0.11335678625972335
0.020431053528085375
0.14293723632449795
```

In [62]:
```python
#The R² value for the test data = 0.6481740917926483,
#which is pretty similar to the train data.

#Since the R² values for both the train and
#test data are almost equal, the model we built is the best-fitted model.
```