lda-wine-quality

December 19, 2023

[52]:
```
# Import necessary libraries
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.metrics import accuracy_score, confusion_matrix,␣
 ↪classification_report
from sklearn.preprocessing import StandardScaler
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import GridSearchCV
```

[53]:
```
df = pd.read_csv("/kaggle/input/red-wine-quality-cortez-et-al-2009/
 ↪winequality-red.csv")
df.head()
```

[53]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	quality
0	7.4	0.70	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	0.56	9.4	5
1	7.8	0.88	0.00	2.6	0.098	25.0	67.0	0.9968	3.20	0.68	9.8	5
2	7.8	0.76	0.04	2.3	0.092	15.0	54.0	0.9970	3.26	0.65	9.8	5
3	11.2	0.28	0.56	1.9	0.075	17.0	60.0	0.9980	3.16	0.58	9.8	6
4	7.4	0.70	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	0.56	9.4	5

[54]:
```
df.columns
```

[54]:
```
Index(['fixed acidity', 'volatile acidity', 'citric acid', 'residual sugar',
       'chlorides', 'free sulfur dioxide', 'total sulfur dioxide', 'density',
       'pH', 'sulphates', 'alcohol', 'quality'],
      dtype='object')
```

[55]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1599 entries, 0 to 1598
Data columns (total 12 columns):
 #   Column                Non-Null Count  Dtype  
---  ------                --------------  -----  
 0   fixed acidity         1599 non-null   float64
 1   volatile acidity      1599 non-null   float64
 2   citric acid           1599 non-null   float64
 3   residual sugar        1599 non-null   float64
 4   chlorides             1599 non-null   float64
 5   free sulfur dioxide   1599 non-null   float64
 6   total sulfur dioxide  1599 non-null   float64
 7   density               1599 non-null   float64
 8   pH                    1599 non-null   float64
 9   sulphates             1599 non-null   float64
 10  alcohol               1599 non-null   float64
 11  quality               1599 non-null   int64  
dtypes: float64(11), int64(1)
memory usage: 150.0 KB
```

[56]:
```
df.describe()
```

[56]:

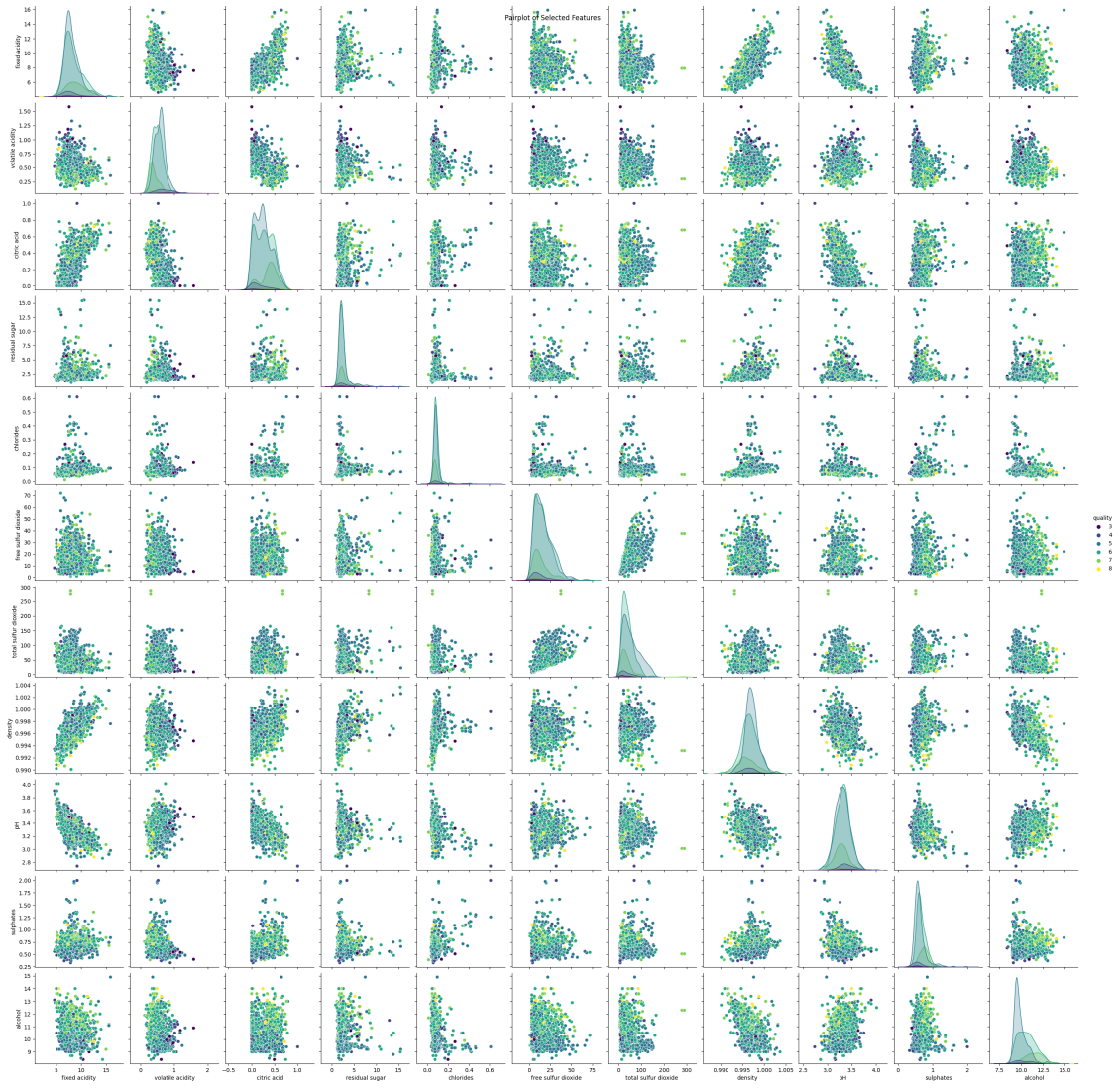
	fixed acidity	volatile acidity	citric acid	residual sugar	\
count	1599.000000	1599.000000	1599.000000	1599.000000	
mean	8.319637	0.527821	0.270976	2.538806	
std	1.741096	0.179060	0.194801	1.409928	
min	4.600000	0.120000	0.000000	0.900000	
25%	7.100000	0.390000	0.090000	1.900000	
50%	7.900000	0.520000	0.260000	2.200000	
75%	9.200000	0.640000	0.420000	2.600000	
max	15.900000	1.580000	1.000000	15.500000	

	chlorides	free sulfur dioxide	total sulfur dioxide	density	\
count	1599.000000	1599.000000	1599.000000	1599.000000	
mean	0.087467	15.874922	46.467792	0.996747	
std	0.047065	10.460157	32.895324	0.001887	
min	0.012000	1.000000	6.000000	0.990070	
25%	0.070000	7.000000	22.000000	0.995600	

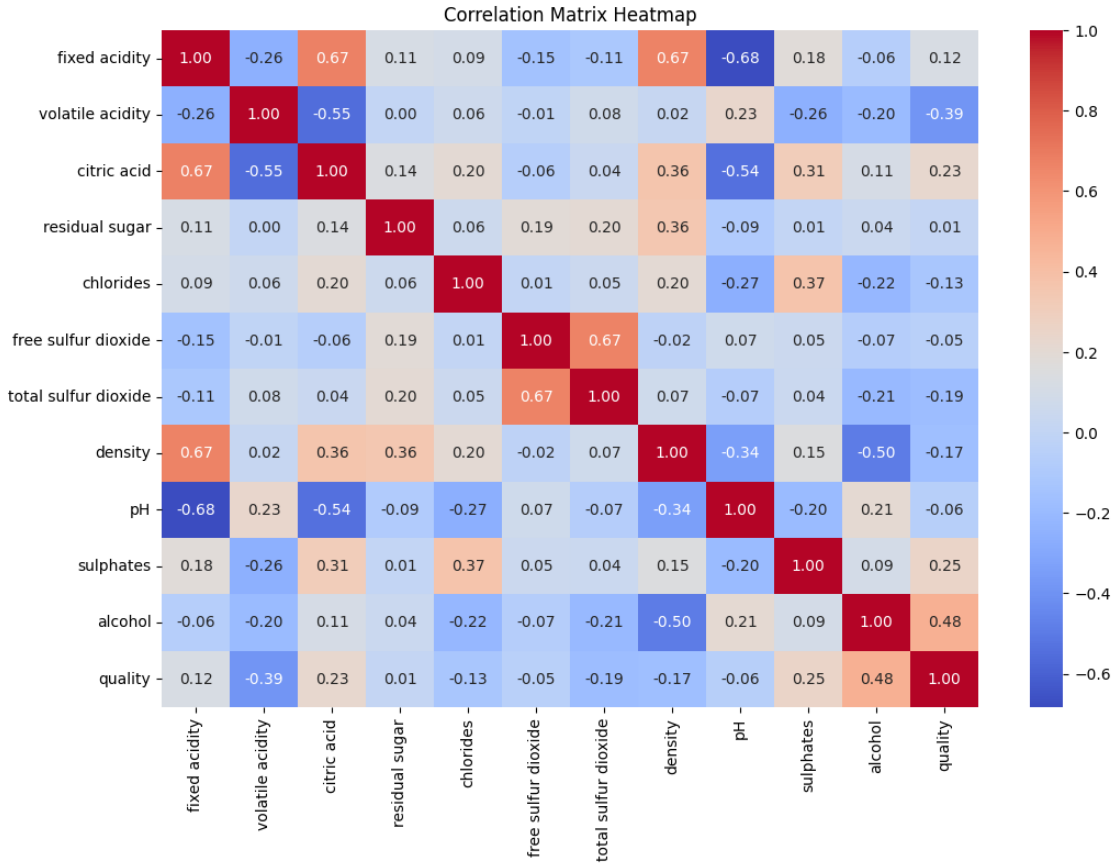
```
50%       0.079000            14.000000             38.000000     0.996750
75%       0.090000            21.000000             62.000000     0.997835
max       0.611000            72.000000            289.000000     1.003690

                pH    sulphates      alcohol      quality
count  1599.000000  1599.000000  1599.000000  1599.000000
mean      3.311113     0.658149    10.422983     5.636023
std       0.154386     0.169507     1.065668     0.807569
min       2.740000     0.330000     8.400000     3.000000
25%       3.210000     0.550000     9.500000     5.000000
50%       3.310000     0.620000    10.200000     6.000000
75%       3.400000     0.730000    11.100000     6.000000
max       4.010000     2.000000    14.900000     8.000000
```

[57]:
```
# Pairplot for selected features
features = ['fixed acidity', 'volatile acidity', 'citric acid', 'residual␣
 ↪sugar', 'chlorides', 'free sulfur dioxide',
            'total sulfur dioxide', 'density', 'pH', 'sulphates', 'alcohol',␣
 ↪'quality']
sns.pairplot(df[features], hue='quality', markers='o', palette='viridis')
plt.suptitle("Pairplot of Selected Features")
plt.show()
```



[58]:
```
# Correlation matrix heatmap
corr_matrix = df.corr()
plt.figure(figsize=(12, 8))
sns.heatmap(corr_matrix, annot=True, cmap='coolwarm', fmt=".2f")
plt.title("Correlation Matrix Heatmap")
plt.show()
```



[59]:
```
# Data preprocessing
X = df.drop('quality', axis=1)
y = df['quality']
```

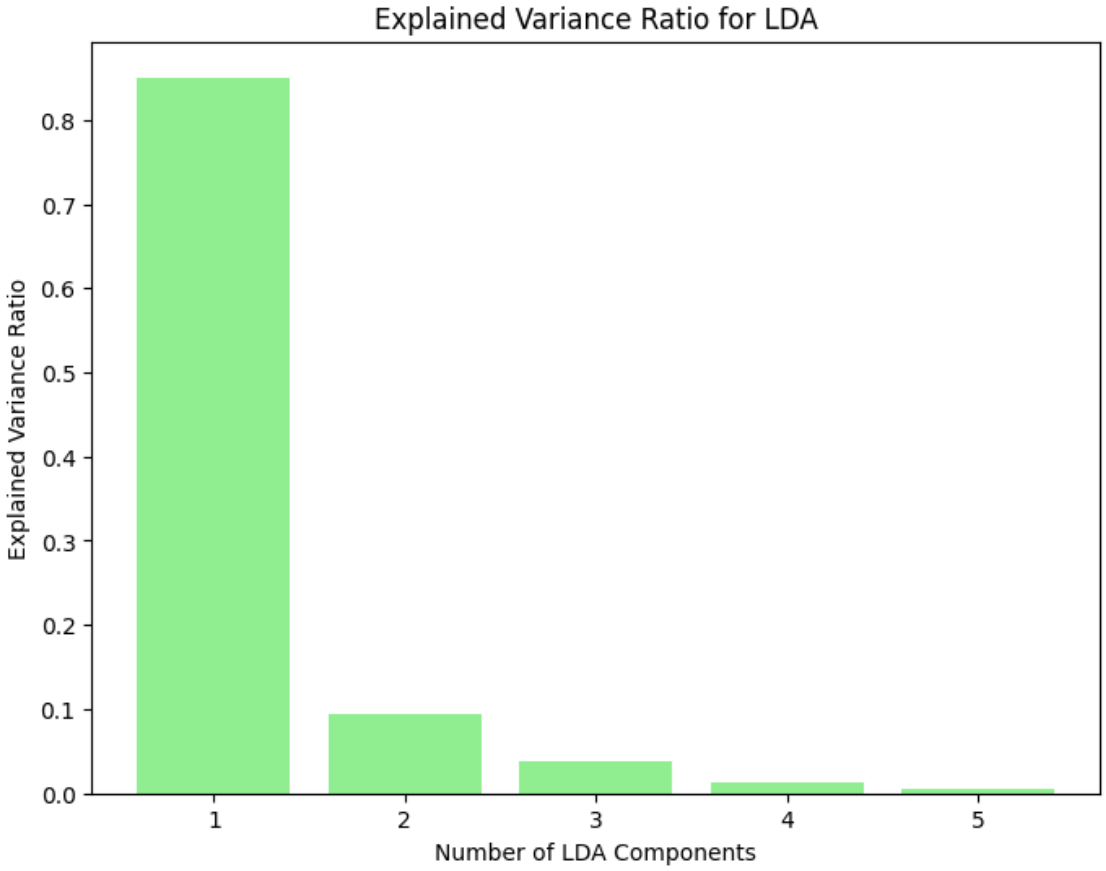
[60]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
↪random_state=42)
```

[61]:
```
# Standardize the features
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)
```

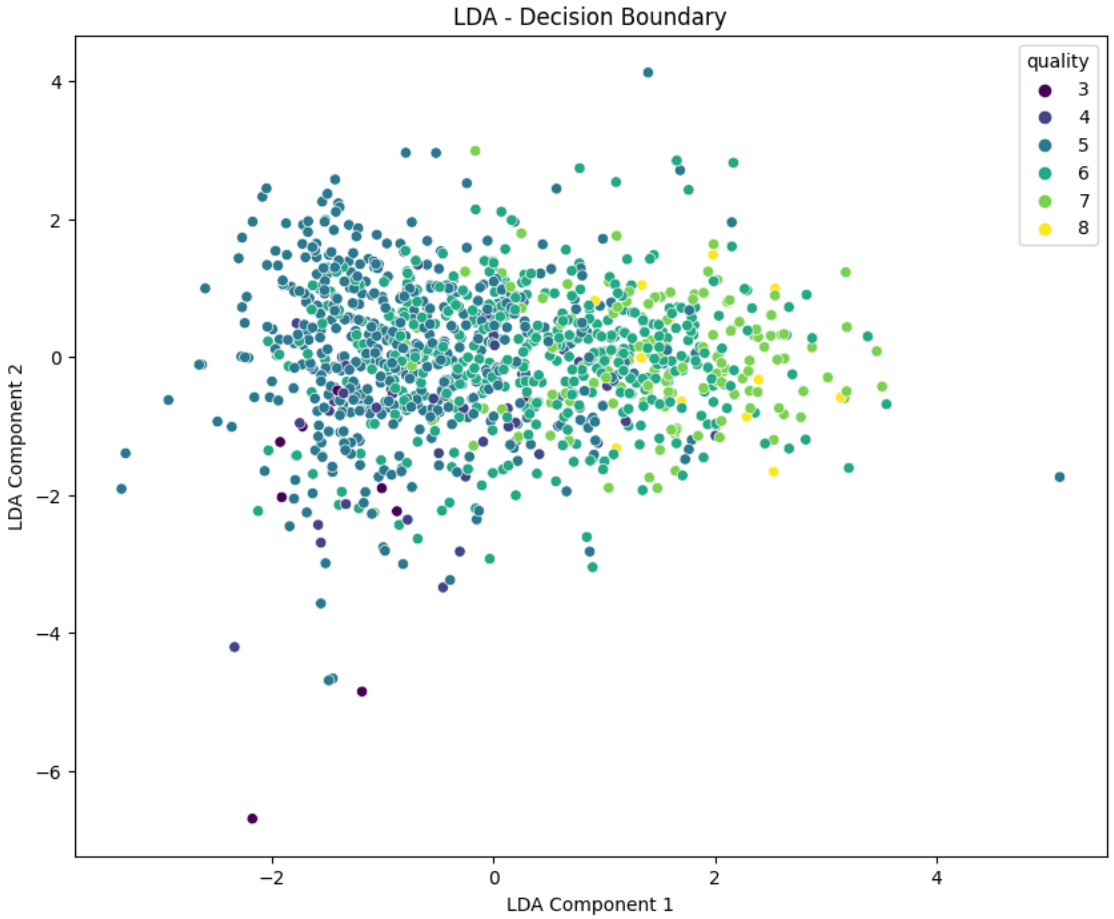
[62]:
```
# Linear Discriminant Analysis (LDA)
lda = LinearDiscriminantAnalysis()
X_train_lda = lda.fit_transform(X_train_scaled, y_train)
X_test_lda = lda.transform(X_test_scaled)
```

[63]:
```
# Plot the explained variance ratio
plt.figure(figsize=(8, 6))
```

```
plt.bar(range(1, lda.explained_variance_ratio_.shape[0] + 1), lda.
  ↪explained_variance_ratio_, color="lightgreen")
plt.xlabel('Number of LDA Components')
plt.ylabel('Explained Variance Ratio')
plt.title('Explained Variance Ratio for LDA')
plt.show()
```



[64]:
```
# Plot the decision boundary
plt.figure(figsize=(10, 8))
sns.scatterplot(x=X_train_lda[:, 0], y=X_train_lda[:, 1], hue=y_train,␣
  ↪palette='viridis')
plt.title('LDA - Decision Boundary')
plt.xlabel('LDA Component 1')
plt.ylabel('LDA Component 2')
plt.show()
```



[65]:
```
# Random Forest Classifier
rf_classifier = RandomForestClassifier(random_state=42)

# Hyperparameter tuning using GridSearchCV
param_grid = {
    'n_estimators': [50, 100, 150],
    'max_depth': [None, 10, 20, 30],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4]
}
```

[66]:
```
grid_search = GridSearchCV(estimator=rf_classifier, param_grid=param_grid,␣
 ↪cv=5, scoring='accuracy')
grid_search.fit(X_train_lda, y_train)
```

[66]:
```
GridSearchCV(cv=5, estimator=RandomForestClassifier(random_state=42),
             param_grid={'max_depth': [None, 10, 20, 30],
                         'min_samples_leaf': [1, 2, 4],
```

```
                           'min_samples_split': [2, 5, 10],
                           'n_estimators': [50, 100, 150]},
                scoring='accuracy')
```

[67]:
```
# Best parameters from the grid search
best_params = grid_search.best_params_

# Use the best model for prediction
best_rf_model = grid_search.best_estimator_
y_pred = best_rf_model.predict(lda.transform(X_test_scaled))
```

[68]:
```
# Model evaluation
accuracy = accuracy_score(y_test, y_pred)
print(f"Accuracy: {accuracy:.2f}")
```

```
Accuracy: 0.64
```

[69]:
```
# Classification Report
print("Classification Report:")
print(classification_report(y_test, y_pred))
```

```
Classification Report:
              precision    recall  f1-score   support

           3       0.00      0.00      0.00         1
           4       0.00      0.00      0.00        10
           5       0.70      0.77      0.74       130
           6       0.62      0.64      0.63       132
           7       0.52      0.52      0.52        42
           8       0.00      0.00      0.00         5

    accuracy                           0.64       320
   macro avg       0.31      0.32      0.31       320
weighted avg       0.61      0.64      0.63       320


/opt/conda/lib/python3.10/site-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/opt/conda/lib/python3.10/site-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
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/opt/conda/lib/python3.10/site-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
```
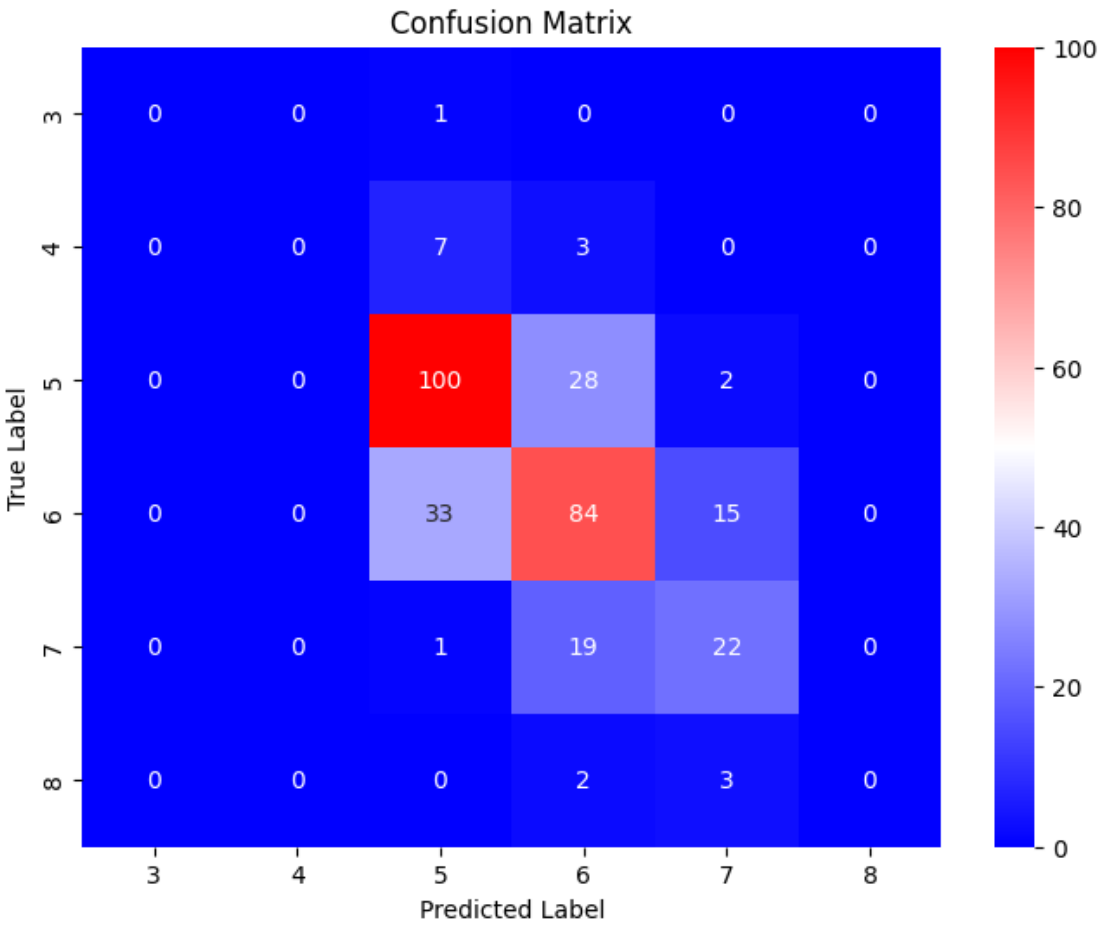

```
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

[70]:
```
# Confusion Matrix
conf_matrix = confusion_matrix(y_test, y_pred)
print("Confusion Matrix:")
print(conf_matrix)
```

```
Confusion Matrix:
[[  0   0   1   0   0   0]
 [  0   0   7   3   0   0]
 [  0   0 100  28   2   0]
 [  0   0  33  84  15   0]
 [  0   0   1  19  22   0]
 [  0   0   0   2   3   0]]
```

[71]:
```
plt.figure(figsize=(8, 6))
sns.heatmap(conf_matrix, annot=True, fmt='d', cmap='bwr',␣
 ↪xticklabels=sorted(y_test.unique()),
            yticklabels=sorted(y_test.unique()))
plt.title('Confusion Matrix')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```


Confusion Matrix
True Label
Predicted Label
3
4
5
6
7
8
0 0 1 0 0 0
0 0 7 3 0 0
0 0 100 28 2 0
0 0 33 84 15 0
0 0 1 19 22 0
0 0 0 2 3 0
100
80
60
40
20
0