In [1]:
```
from sklearn.feature_extraction.text import TfidfTransformer, TfidfVectorizer,CountVec
from sklearn import metrics
from sklearn.metrics import accuracy_score, confusion_matrix
from sklearn.feature_selection import SelectKBest, mutual_info_classif
import nltk
import pandas as pd
import numpy as np
from sklearn.pipeline import Pipeline
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn import preprocessing, linear_model, metrics, datasets, multiclass, svm
from sklearn.model_selection import train_test_split, cross_val_score, KFold
import seaborn as sns
from sklearn.ensemble import RandomForestClassifier, AdaBoostClassifier
from sklearn import metrics
```

In [2]:
```
# loading data
df = pd.read_csv('./Consumer_Complaints.csv')
df.shape
```

```
C:\Users\admin\AppData\Local\Temp\ipykernel_11692\98951488.py:2: DtypeWarning: Column
s (5,11) have mixed types. Specify dtype option on import or set low_memory=False.
  df = pd.read_csv('./Consumer_Complaints.csv')
```

Out[2]:
```
(670598, 18)
```

In [3]:
```
df['ZIP code']=df['ZIP code'].astype(str)
print(df.dtypes)
```

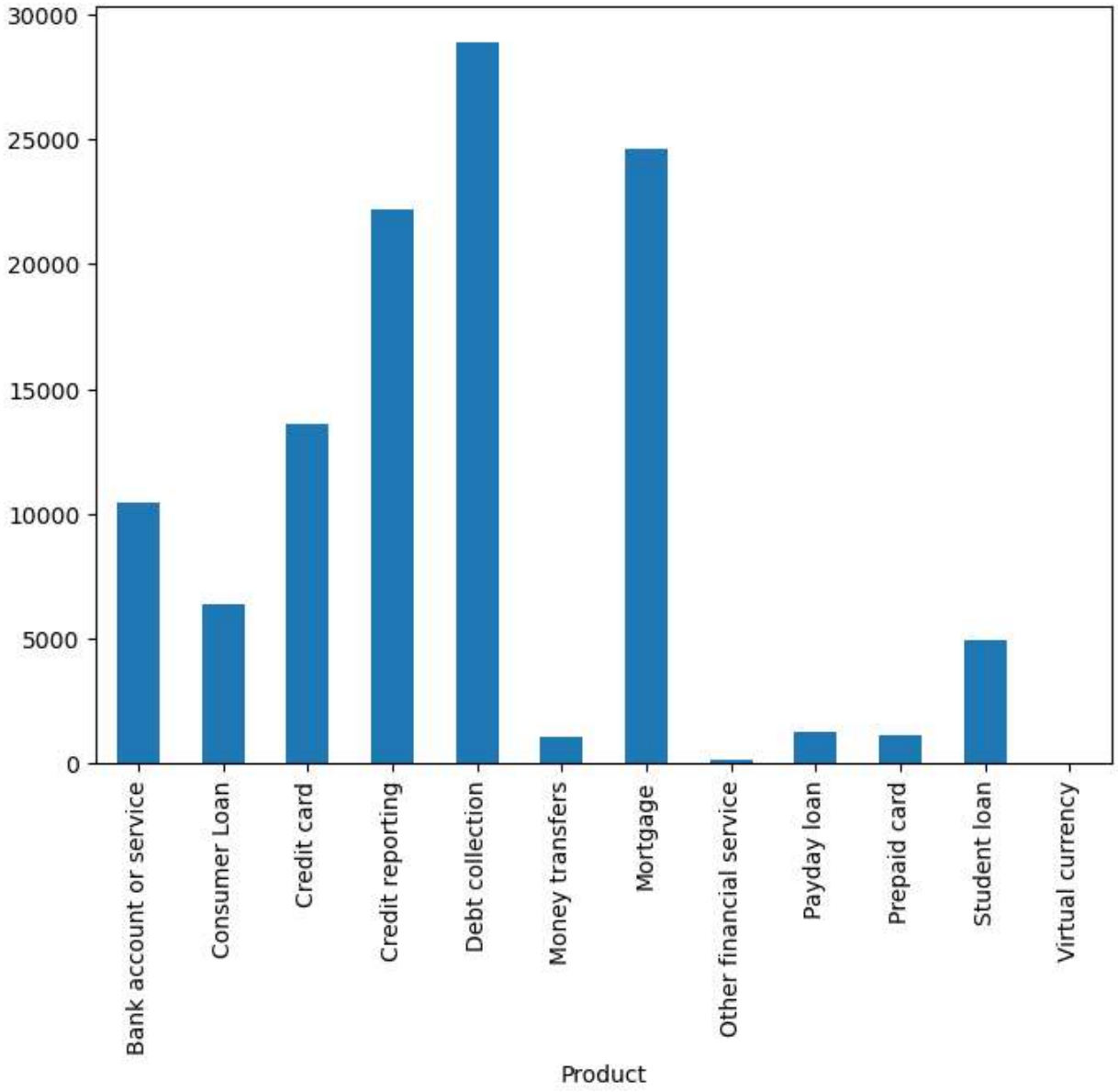
```
Date received                   object
Product                         object
Sub-product                     object
Issue                           object
Sub-issue                       object
Consumer complaint narrative    object
Company public response         object
Company                         object
State                           object
ZIP code                        object
Tags                            object
Consumer consent provided?      object
Submitted via                   object
Date sent to company            object
Company response to consumer    object
Timely response?                object
Consumer disputed?              object
Complaint ID                     int64
dtype: object
```

In [4]:
```
df.head(2).T # Columns are shown in rows for easy reading
```

Out[4]:

	0	1
Date received	07/29/2013	07/29/2013
Product	Consumer Loan	Bank account or service
Sub-product	Vehicle loan	Checking account
Issue	Managing the loan or lease	Using a debit or ATM card
Sub-issue	NaN	NaN
Consumer complaint narrative	NaN	NaN
Company public response	NaN	NaN
Company	Wells Fargo & Company	Wells Fargo & Company
State	VA	CA
ZIP code	24540	95992
Tags	NaN	Older American
Consumer consent provided?	NaN	NaN
Submitted via	Phone	Web
Date sent to company	07/30/2013	07/31/2013
Company response to consumer	Closed with explanation	Closed with explanation
Timely response?	Yes	Yes
Consumer disputed?	No	No
Complaint ID	468882	468889

In [5]:
```
fig = plt.figure(figsize=(8,6))
df.groupby('Product')['Consumer complaint narrative'].count().plot.bar()
plt.show()
```



In [6]:
```
total = df['Consumer complaint narrative'].notnull().sum()
round((total/len(df)*100),1)
```

Out[6]:
```
17.1
```

In [7]:
```
df.dtypes
```

Out[7]:
```
Date received                 object
Product                       object
Sub-product                   object
Issue                         object
Sub-issue                     object
Consumer complaint narrative  object
Company public response       object
Company                       object
State                         object
ZIP code                      object
Tags                          object
Consumer consent provided?    object
Submitted via                 object
Date sent to company          object
Company response to consumer  object
Timely response?              object
Consumer disputed?            object
Complaint ID                   int64
dtype: object
```

In [8]:
```
pd.notnull(df['Consumer complaint narrative']).value_counts()
```

Out[8]:
```
False    555894
True     114704
Name: Consumer complaint narrative, dtype: int64
```

In [9]:
```
Data = df[['Product','Consumer complaint narrative']]
Data = Data[pd.notnull(Data['Consumer complaint narrative'])]
Data
```

Out[9]:

	Product	Consumer complaint narrative
57729	Credit card	Received Capital One charge card offer XXXX. A...
57787	Debt collection	I do n't know how they got my cell number. I t...
57838	Credit card	I 'm a longtime member of Charter One Bank/RBS...
57848	Credit reporting	After looking at my credit report, I saw a col...
57852	Debt collection	I received a call from a XXXX XXXX from XXXX @...
...	...	...
670582	Mortgage	My mother XXXX in XXXX with a reverse mortgage...
670588	Credit card	Chase rejects customer payments claiming that ...
670590	Credit card	I filed for chapter XXXX protection 5 years ag...
670594	Mortgage	We purchased our home in XX/XX/XXXX at the pea...
670596	Credit card	I have had an American Express card for over t...

114704 rows × 2 columns

In [10]:
```
Data.shape
```

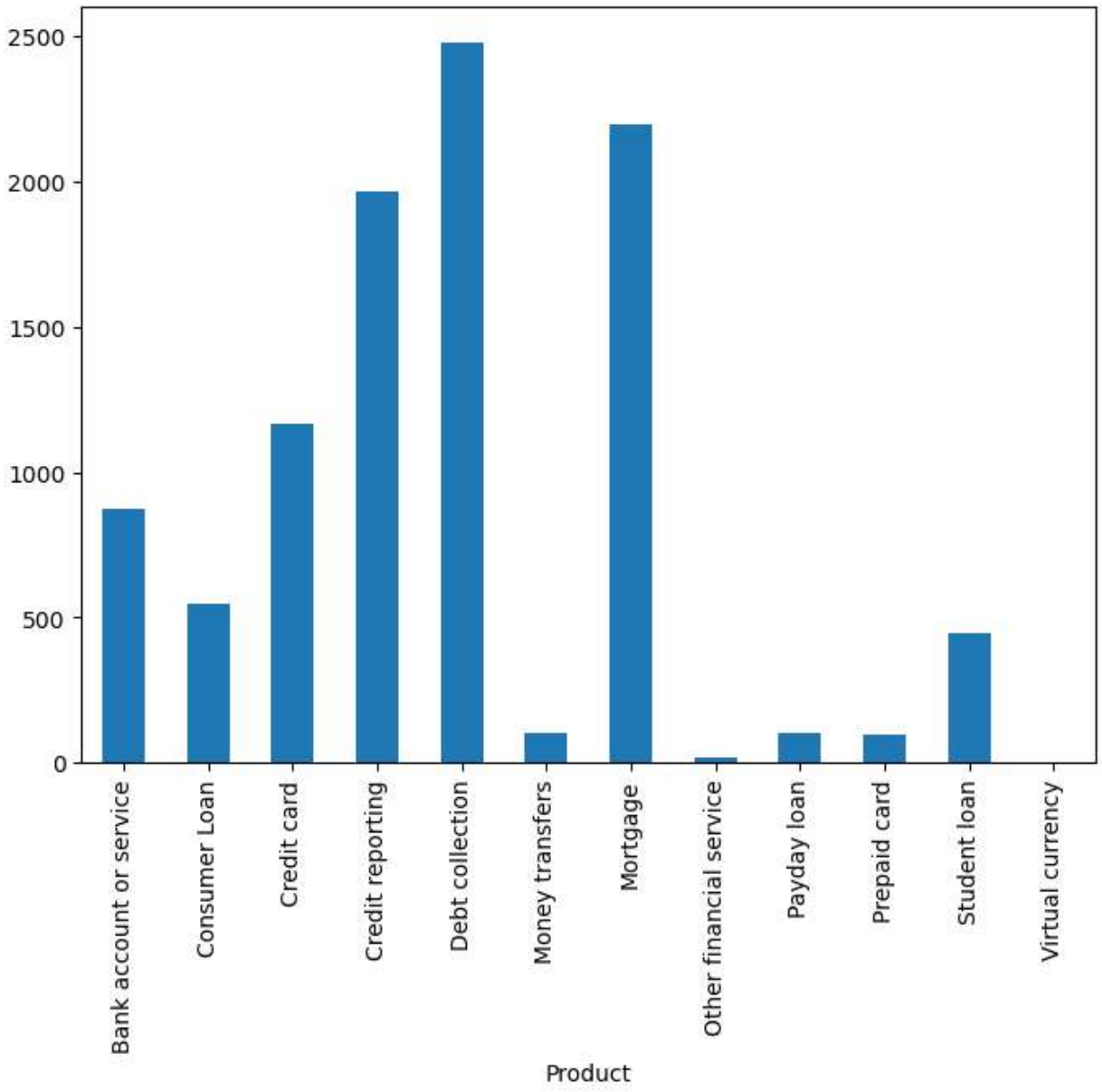
Out[10]:
```
(114704, 2)
```

In [11]:
```
Data = Data.sample(n=10000, random_state=42)
```

In [12]:
```
Data.groupby('Product')['Consumer complaint narrative'].count()
```

Out[12]:
```
Product
Bank account or service     872
Consumer Loan               545
Credit card                1169
Credit reporting           1967
Debt collection            2477
Money transfers             103
Mortgage                   2199
Other financial service      16
Payday loan                 104
Prepaid card                 99
Student loan                448
Virtual currency              1
Name: Consumer complaint narrative, dtype: int64
```

In [13]:
```
fig = plt.figure(figsize=(8,6))
Data.groupby('Product')['Consumer complaint narrative'].count().plot.bar()
plt.show()
```



Pre processing

In [14]:
```
pd.DataFrame(df.Product.unique()).values
```

Out[14]:
```
array([['Consumer Loan'],
       ['Bank account or service'],
       ['Mortgage'],
       ['Debt collection'],
       ['Credit card'],
       ['Credit reporting'],
       ['Student loan'],
       ['Money transfers'],
       ['Payday loan'],
       ['Other financial service'],
       ['Prepaid card'],
       ['Virtual currency']], dtype=object)
```

In [15]:
```
df2 = Data.sample(10000, random_state=1).copy()
df2.replace({'Product':
```

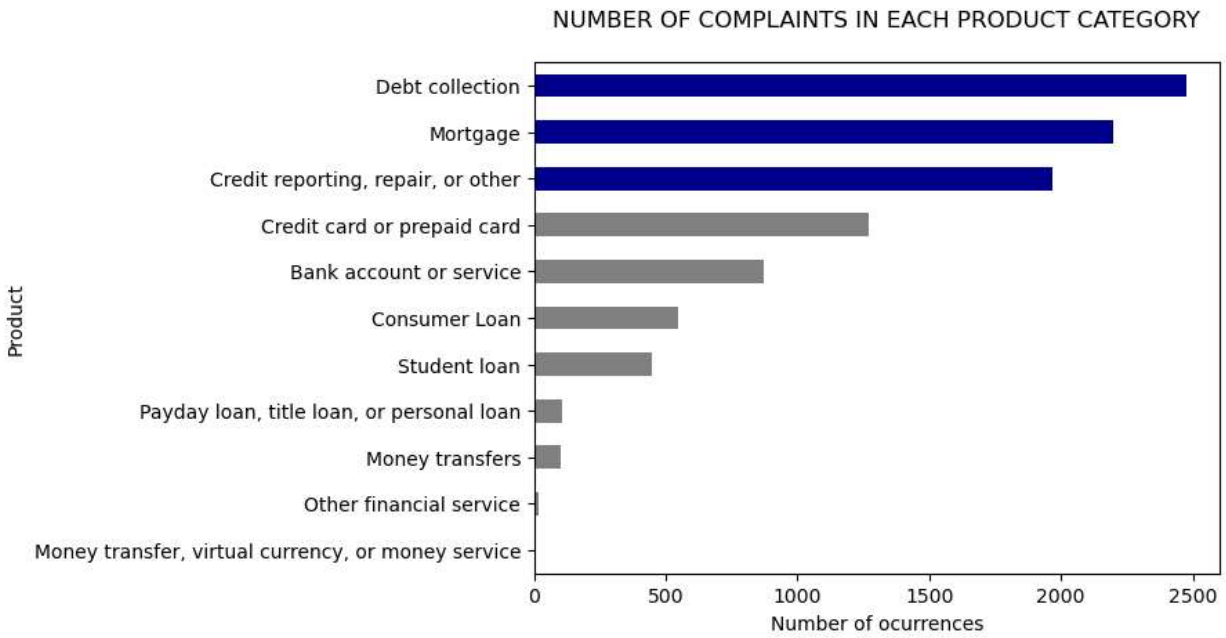
```
             {'Credit reporting, credit repair services, or other personal consumer re
              'Credit reporting, repair, or other',
              'Credit reporting': 'Credit reporting, repair, or other',
             'Credit card': 'Credit card or prepaid card',
             'Prepaid card': 'Credit card or prepaid card',
             'Payday loan': 'Payday loan, title loan, or personal loan',
             'Money transfer': 'Money transfer, virtual currency, or money service',
             'Virtual currency': 'Money transfer, virtual currency, or money service']
            inplace= True)
df2['category_id'] = df2['Product'].factorize()[0]
category_id_df = df2[['Product', 'category_id']].drop_duplicates()


category_to_id = dict(category_id_df.values)
id_to_category = dict(category_id_df[['category_id', 'Product']].values)

df2.head()
```

Out[15]:

	Product	Consumer complaint narrative	category_id
583156	Bank account or service	My name is XXXX XXXX. XXXX XXXX, XXXX I made a...	0
622141	Debt collection	I have attempted to obtain validation of this ...	1
64430	Payday loan, title loan, or personal loan	Hello, This loan I borrowed from XXXX Cash on ...	2
517240	Mortgage	I own a condo in a building on the beach in XX...	3
234385	Credit reporting, repair, or other	They have n't removed XXXX address where I hav...	4

In [16]:

```
fig = plt.figure()
colors = ['grey','grey','grey','grey','grey','grey','grey',
    'grey','darkblue','darkblue','darkblue']
df2.groupby('Product')['Consumer complaint narrative'].count().sort_values().plot.bark
    ylim=0, color=colors, title= 'NUMBER OF COMPLAINTS IN EACH PRODUCT CATEGORY\n')
plt.xlabel('Number of ocurrences', fontsize = 10);
```



In [17]:
```
tfidf = TfidfVectorizer(sublinear_tf=True, min_df=5,
                        ngram_range=(1, 2),
                        stop_words='english')

# We transform each complaint into a vector
features = tfidf.fit_transform(df2['Consumer complaint narrative']).toarray()

labels = df2.category_id

print("Each of the %d complaints is represented by %d features (TF-IDF score of unigra
```

```
Each of the 10000 complaints is represented by 26548 features (TF-IDF score of unigra
ms and bigrams)
```

In [18]:
```
X = df2['Consumer complaint narrative'] # Collection of documents
y = df2['Product'] # Target or the labels we want to predict (i.e., the 13 different c

train_x, valid_x,  train_y, valid_y = train_test_split(X, y,
                                                       test_size=0.25,
                                                       random_state = 0)
```

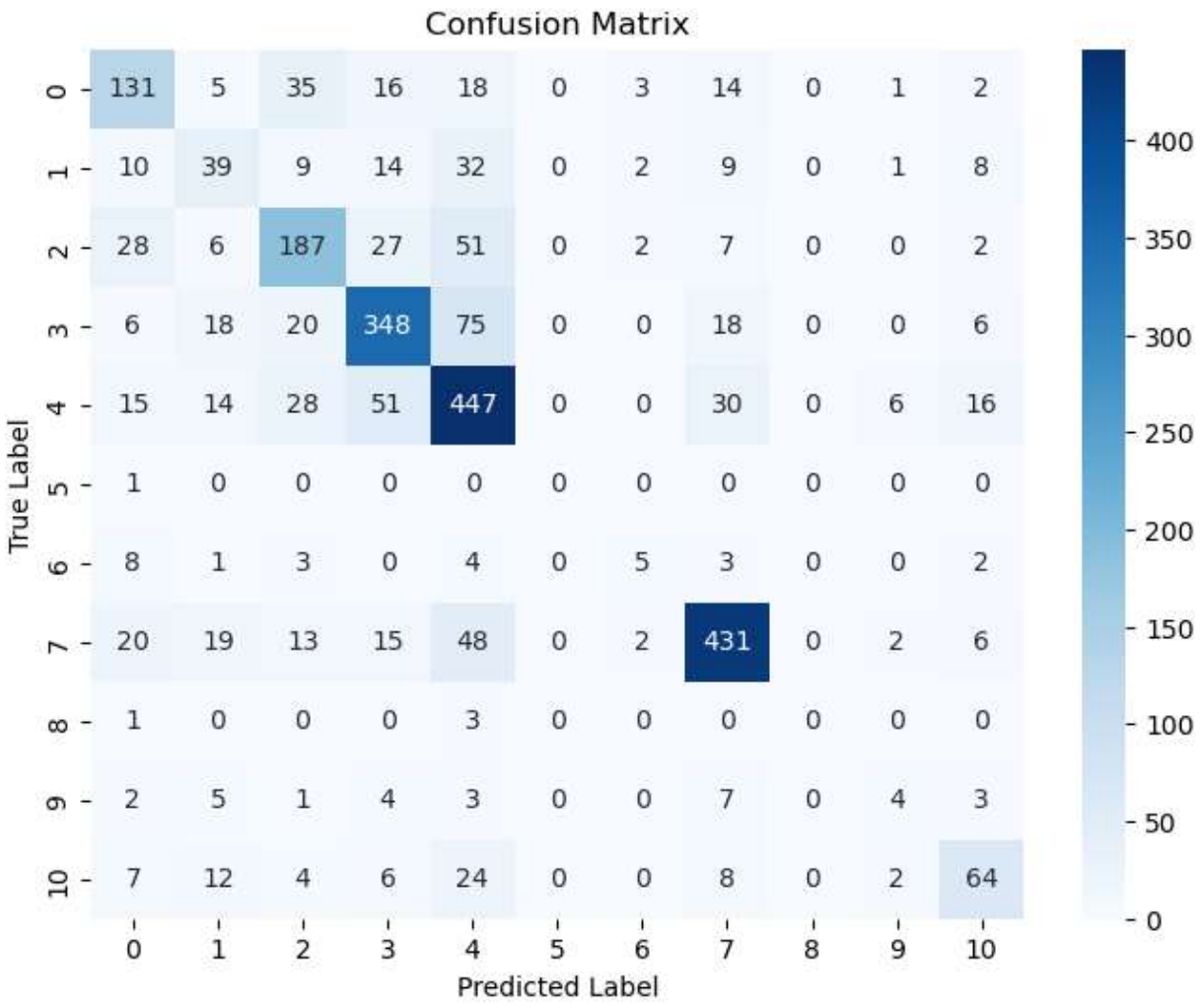
Training

In [ ]:
```
pipeline = Pipeline([
    ('vect', TfidfVectorizer(analyzer='word', token_pattern='\w{1,}', max_features=500
    ('tfidf', TfidfTransformer()),
    ('feature_selection', SelectKBest(score_func=mutual_info_classif,k=5000)),
    ('clf', DecisionTreeClassifier(criterion='gini', max_depth=25))
])

# Fit the GridSearchCV on the training data
pipeline.fit(train_x, train_y)
```

In [57]:
```
# Predict the labels for the validation data
predicted = pipeline.predict(valid_x)
```

```
# Calculate the accuracy
accuracy = accuracy_score(valid_y, predicted)
print("Accuracy:", accuracy)

# Print the confusion matrix
confusion_mat = confusion_matrix(valid_y, predicted)
print("Confusion Matrix:")
print(confusion_mat)
# Confusion Matrix
plt.figure(figsize=(8, 6))
sns.heatmap(confusion_mat, annot=True, fmt='d', cmap='Blues')
plt.title('Confusion Matrix')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```

```
Accuracy: 0.6624
Confusion Matrix:
[[131   5  35  16  18   0   3  14   0   1   2]
 [ 10  39   9  14  32   0   2   9   0   1   8]
 [ 28   6 187  27  51   0   2   7   0   0   2]
 [  6  18  20 348  75   0   0  18   0   0   6]
 [ 15  14  28  51 447   0   0  30   0   6  16]
 [  1   0   0   0   0   0   0   0   0   0   0]
 [  8   1   3   0   4   0   5   3   0   0   2]
 [ 20  19  13  15  48   0   2 431   0   2   6]
 [  1   0   0   0   3   0   0   0   0   0   0]
 [  2   5   1   4   3   0   0   7   0   4   3]
 [  7  12   4   6  24   0   0   8   0   2  64]]
```



In [58]:
```
print("Classification Report:")
print(metrics.classification_report(valid_y, predicted))
```

```
Classification Report:
                                                    precision    recall  f1-score   s
upport

                           Bank account or service       0.57      0.58      0.58
225
                                     Consumer Loan       0.33      0.31      0.32
124
                       Credit card or prepaid card       0.62      0.60      0.61
310
                Credit reporting, repair, or other       0.72      0.71      0.72
491
                                   Debt collection       0.63      0.74      0.68
607
Money transfer, virtual currency, or money service       0.00      0.00      0.00
1
                                   Money transfers       0.36      0.19      0.25
26
                                          Mortgage       0.82      0.78      0.80
556
                           Other financial service       0.00      0.00      0.00
4
         Payday loan, title loan, or personal loan       0.25      0.14      0.18
29
                                      Student loan       0.59      0.50      0.54
127

                                          accuracy                           0.66
2500
                                         macro avg       0.44      0.41      0.42
2500
                                      weighted avg       0.66      0.66      0.66
2500
```

```
C:\Users\admin\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1469: U
ndefinedMetricWarning: 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 behav
ior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\admin\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1469: U
ndefinedMetricWarning: 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 behav
ior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\admin\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1469: U
ndefinedMetricWarning: 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 behav
ior.
  _warn_prf(average, modifier, msg_start, len(result))
```

In [ ]:

```
pipeline = Pipeline([
    ('vect', TfidfVectorizer(analyzer='word', token_pattern='\w{1,}', max_features=50(
    ('tfidf', TfidfTransformer()),
    ('feature_selection', SelectKBest(score_func=mutual_info_classif, k=800)),
    ('clf', RandomForestClassifier(criterion='gini', max_depth=25,n_estimators=200))
])

# Fit the GridSearchCV on the training data
pipeline.fit(train_x, train_y)
```

In [34]:
```
# Predict the labels for the validation data
predicted = pipeline.predict(valid_x)

# Calculate the accuracy
accuracy = accuracy_score(valid_y, predicted)
print("Accuracy:", accuracy)

# Print the confusion matrix
confusion_mat = confusion_matrix(valid_y, predicted)
print("Confusion Matrix:")
print(confusion_mat)
```

```
Accuracy: 0.7732
Confusion Matrix:
[[155   0  32  15  15   0   0   8   0   0   0]
 [  3  38   6  15  33   0   0  27   0   0   2]
 [ 13   0 220  30  39   0   0   8   0   0   0]
 [  0   3   7 420  46   0   0  14   0   0   1]
 [  5   1  16  50 502   0   0  26   0   0   7]
 [  1   0   0   0   0   0   0   0   0   0   0]
 [  7   1   5   0  11   0   0   2   0   0   0]
 [  3   0   4   8  22   0   0 519   0   0   0]
 [  2   0   0   1   0   0   0   1   0   0   0]
 [  2   2   0   1  13   0   0   8   0   0   3]
 [  1   0   4   8  25   0   0  10   0   0  79]]
```

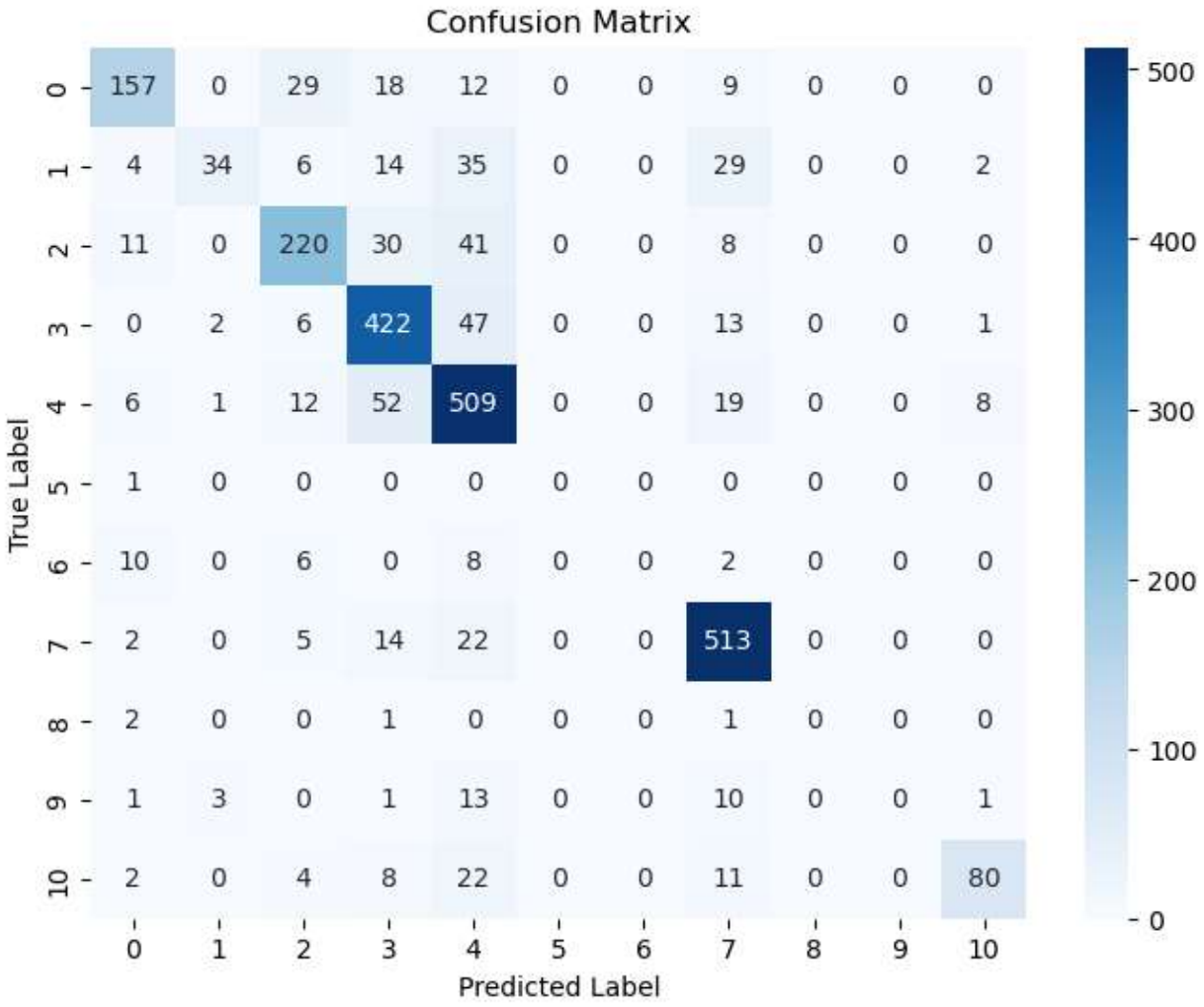
In [35]:
```
print("Classification Report:")
print(metrics.classification_report(valid_y, predicted))
```

```
Classification Report:
                                                    precision    recall  f1-score   s
upport

                         Bank account or service       0.81      0.69      0.74
225
                                   Consumer Loan       0.84      0.31      0.45
124
                     Credit card or prepaid card       0.75      0.71      0.73
310
              Credit reporting, repair, or other       0.77      0.86      0.81
491
                                 Debt collection       0.71      0.83      0.76
607
Money transfer, virtual currency, or money service       0.00      0.00      0.00
1
                                 Money transfers       0.00      0.00      0.00
26
                                        Mortgage       0.83      0.93      0.88
556
                         Other financial service       0.00      0.00      0.00
4
           Payday loan, title loan, or personal loan       0.00      0.00      0.00
29
                                    Student loan       0.86      0.62      0.72
127

                                        accuracy                           0.77
2500
                                       macro avg       0.51      0.45      0.46
2500
                                    weighted avg       0.76      0.77      0.76
2500
```

```
C:\Users\admin\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1469: U
ndefinedMetricWarning: 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 behav
ior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\admin\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1469: U
ndefinedMetricWarning: 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 behav
ior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\admin\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1469: U
ndefinedMetricWarning: 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 behav
ior.
  _warn_prf(average, modifier, msg_start, len(result))
```

In [21]:

```
# Confusion Matrix
plt.figure(figsize=(8, 6))
sns.heatmap(confusion_mat, annot=True, fmt='d', cmap='Blues')
plt.title('Confusion Matrix')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```



In [ ]:
```
from sklearn.model_selection import GridSearchCV
pipeline = Pipeline([
    ('vect', TfidfVectorizer(analyzer='word', token_pattern='\w{1,}', max_features=500
    ('tfidf', TfidfTransformer()),
    ('feature_selection', SelectKBest(score_func=mutual_info_classif)),
    ('clf', DecisionTreeClassifier())
])

param_grid = {
    'feature_selection__k': [1000,2000,3000],
    'clf__criterion': ['gini', 'entropy'],
    'clf__max_depth': [10, 15,20,25,30],
}

# Create a GridSearchCV instance
grid_search = GridSearchCV(pipeline, param_grid=param_grid, cv=5)

# Fit the GridSearchCV on the training data
grid_search.fit(train_x, train_y)

# Access the results
results = grid_search.cv_results_
params = results['params']
mean_scores = results['mean_test_score']

# Extract the hyperparameters and scores
param_names = [str(param) for param in params]
```

```
x_pos = np.arange(len(param_names))
scores = np.array(mean_scores)
# Get the best model
best_model = grid_search.best_estimator_
best_params = grid_search.best_params_

# Print the best model's parameters
print("Best Parameters:")
for param, value in best_params.items():
    print(f"{param}: {value}")

# Fit the best model on the training data
best_model.fit(train_x, train_y)

# Predict the labels for the validation data
predicted = best_model.predict(valid_x)

# Calculate the accuracy
accuracy = accuracy_score(valid_y, predicted)
print("Accuracy:", accuracy)

# Print the confusion matrix
confusion_mat = confusion_matrix(valid_y, predicted)
print("Confusion Matrix:")
print(confusion_mat)
```

Best Parameters: clf__criterion: gini clf__max_depth: 15 feature_selection__k: 3000 Accuracy: 0.6764 Confusion Matrix: [[128 2 26 10 37 1 7 0 0 3 1] [12 56 4 14 39 0 11 0 0 0 1] [31 5 167 24 65 0 6 0 0 5 1] [7 8 15 348 89 0 15 0 0 1 4] [16 17 22 40 479 0 15 0 1 0 14] [7 0 2 0 20 2 1 0 0 0 1] [19 21 4 9 61 0 441 0 0 0 2] [1 0 1 0 1 0 1 0 0 0 1] [3 5 1 2 9 0 1 0 0 0 0] [9 0 6 0 10 0 0 0 0 4 0] [0 13 2 3 19 0 4 0 1 0 66]]

In [ ]:

```
from sklearn.ensemble import RandomForestClassifier

pipeline2 = Pipeline([
    ('vect', TfidfVectorizer(analyzer='word', token_pattern='\w{1,}', max_features=500
    ('tfidf', TfidfTransformer()),
    ('feature_selection', SelectKBest(score_func=mutual_info_classif,)),
    ('clf', RandomForestClassifier())
])

param_grid2 = {
    'feature_selection__k': [200,400,600,800,1000],
    'clf__n_estimators': [100, 200, 300],
    'clf__max_depth': [15,20,25,30,35,40],
}

# Create a GridSearchCV instance
grid_search2 = GridSearchCV(pipeline2, param_grid=param_grid2, cv=5)

# Fit the GridSearchCV on the training data
grid_search2.fit(train_x, train_y)

# Access the results
results2 = grid_search2.cv_results_
params2 = results2['params']
mean_scores2 = results2['mean_test_score']

# Extract the hyperparameters and scores
param_names2 = [str(param) for param in params2]
x_pos2 = np.arange(len(param_names2))
```

```
scores2 = np.array(mean_scores2)
# Get the best model
best_model2 = grid_search2.best_estimator_
best_params2 = grid_search2.best_params_

# Print the best model's parameters
print("Best Parameters:")
for param, value in best_params2.items():
    print(f"{param}: {value}")

# Fit the best model on the training data
best_model2.fit(train_x, train_y)

# Predict the labels for the validation data
predicted2 = best_model2.predict(valid_x)

# Calculate the accuracy
accuracy2 = accuracy_score(valid_y, predicted2)
print("Accuracy:", accuracy2)

# Print the confusion matrix
confusion_mat2 = confusion_matrix(valid_y, predicted2)
print("Confusion Matrix:")
print(confusion_mat2)
```

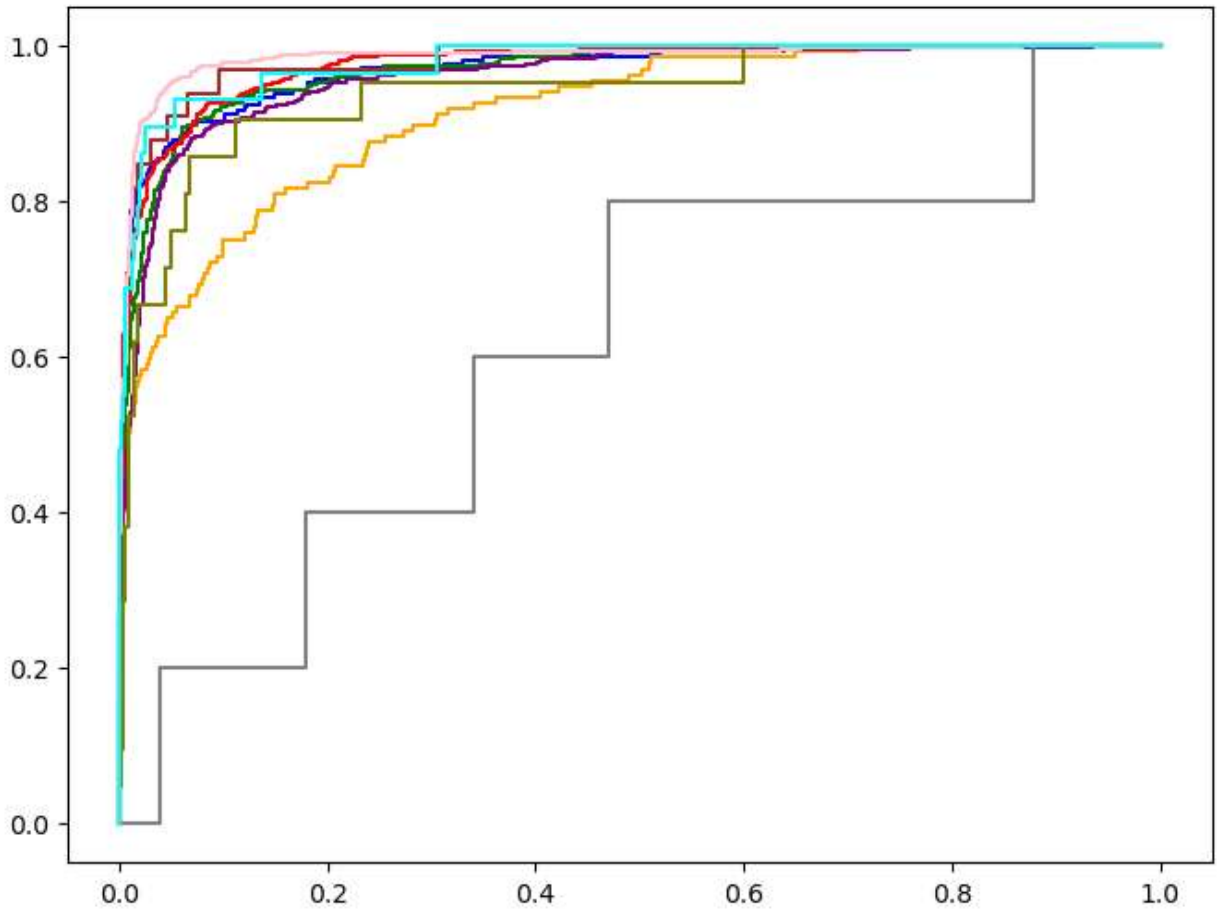
Best Parameters: clf__max_depth: 30 clf__n_estimators: 200 feature_selection__k: 800 Accuracy: 0.7788 Confusion Matrix: [[165 3 16 12 8 1 10 0 0 0 0] [3 60 5 19 35 0 14 0 1 0 0] [16 2 211 28 37 0 10 0 0 0 0] [3 4 11 406 52 0 10 0 0 0 1] [9 4 18 35 510 0 18 0 0 0 10] [7 1 3 0 14 6 2 0 0 0 0] [9 4 2 12 26 0 503 0 0 0 1] [2 0 1 0 0 0 1 0 0 0 1] [3 6 0 2 8 0 1 0 1 0 0] [8 0 9 2 2 0 0 0 0 8 0] [2 2 0 7 12 0 8 0 0 0 77]]

In [67]:

```
from sklearn.preprocessing import LabelBinarizer
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import  auc
from sklearn.metrics import confusion_matrix, roc_curve, precision_recall_curve
from sklearn.inspection import permutation_importance
from sklearn.model_selection import learning_curve, validation_curve
lb = LabelBinarizer()
valid_y_encoded = lb.fit_transform(valid_y)

# ROC Curve
y_scores2 = final_pipeline3.predict_proba(valid_x)
n_classes2 = len(lb.classes_)

fpr2 = dict()
tpr2 = dict()
roc_auc2 = dict()

for i in range(n_classes2):
    fpr2[i], tpr2[i], _ = roc_curve(valid_y_encoded[:, i], y_scores2[:, i])
    roc_auc2[i] = auc(fpr2[i], tpr2[i])

plt.figure(figsize=(8, 6))
colors = ['blue', 'orange', 'green', 'red', 'purple', 'brown', 'pink', 'gray', 'olive'
for i in range(n_classes2):
    plt.plot(fpr2[i], tpr2[i], color=colors[i], label='Class %d (AUC = %0.2f)' % (i, r

plt.plot([0, 1], [0, 1], color='black', linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
```

```
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.legend(loc='lower right')
plt.show()
```

```
---------------------------------------------------------------------------
IndexError                                Traceback (most recent call last)
~\AppData\Local\Temp\ipykernel_5072\3430061750.py in <module>
     24 colors = ['blue', 'orange', 'green', 'red', 'purple', 'brown', 'pink', 'gra
y', 'olive', 'cyan']
     25 for i in range(n_classes2):
---> 26     plt.plot(fpr2[i], tpr2[i], color=colors[i], label='Class %d (AUC = %0.2
f)' % (i, roc_auc2[i]))
     27
     28 plt.plot([0, 1], [0, 1], color='black', linestyle='--')

IndexError: list index out of range
```



In [42]:
```
complaint = ["""student school study college highschool loan"""
]
#text_features = tfidf_vect.transform(texts)
predictions = pipeline.predict(complaint)
# print(predictions)
print("   -Predicted as",predictions[0])
```

```
   -Predicted as Student loan
```

In [36]:
```
import pickle
# save the model to disk
```

```
filename = 'finalized_model.sav'
pickle.dump(pipeline, open(filename, 'wb'))
```

In [37]:
```
loaded_model = pickle.load(open(filename, 'rb'))
```

In [39]:
```
complaint = ["""student school  loan"""
]
#text_features = tfidf_vect.transform(texts)
predictions = loaded_model.predict(complaint)
# print(predictions)
print("   -Predicted as",predictions[0])
```

```
   -Predicted as Student loan
```

In [ ]:
```

```