CMPS 261 Project

In [ ]:
```
# Importing all necessary libraries

# Data handling
import pandas as pd
import numpy as np

# Text preprocessing
import re
import string
import spacy
from spacy.lang.en.stop_words import STOP_WORDS
from collections import Counter

# Feature extraction
from sklearn.feature_extraction.text import TfidfVectorizer

# Handling imbalance
from imblearn.over_sampling import SMOTE
from sklearn.utils.class_weight import compute_class_weight

# Models
from sklearn.naive_bayes import MultinomialNB
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier
from sklearn.linear_model import LogisticRegression

# Evaluation
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.metrics import classification_report, confusion_matrix, accu

# Neural Network
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
from tensorflow.keras.utils import to_categorical

# Visualization
import matplotlib.pyplot as plt
import seaborn as sns
from wordcloud import WordCloud
```

EXPLORATORY STAGE

In [ ]:
```
# Loading the dataset

df = pd.read_csv("Sentiment_analysis_dataset.csv")  # Replace with your a

# Quick look
df.head()
df.info()
df.describe()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 37130 entries, 0 to 37129
Data columns (total 2 columns):
 #   Column     Non-Null Count  Dtype 
---  ------     --------------  ----- 
 0   Statement  36876 non-null  object
 1   Status     37130 non-null  object
dtypes: object(2)
memory usage: 580.3+ KB
```

Out[ ]:

	Statement	Status
count	36876	37130
unique	36069	7
top	what do you mean?	Normal
freq	15	11446

In [ ]:
```
# Rename columns for consistency (optional)
df.columns = ['Statement', 'Status']
```

In [ ]:
```
# Drop null values in Statement
df = df.dropna(subset=['Statement'])

# Drop exact duplicates
df = df.drop_duplicates()

print(f"Dataset shape after cleaning: {df.shape}")
```

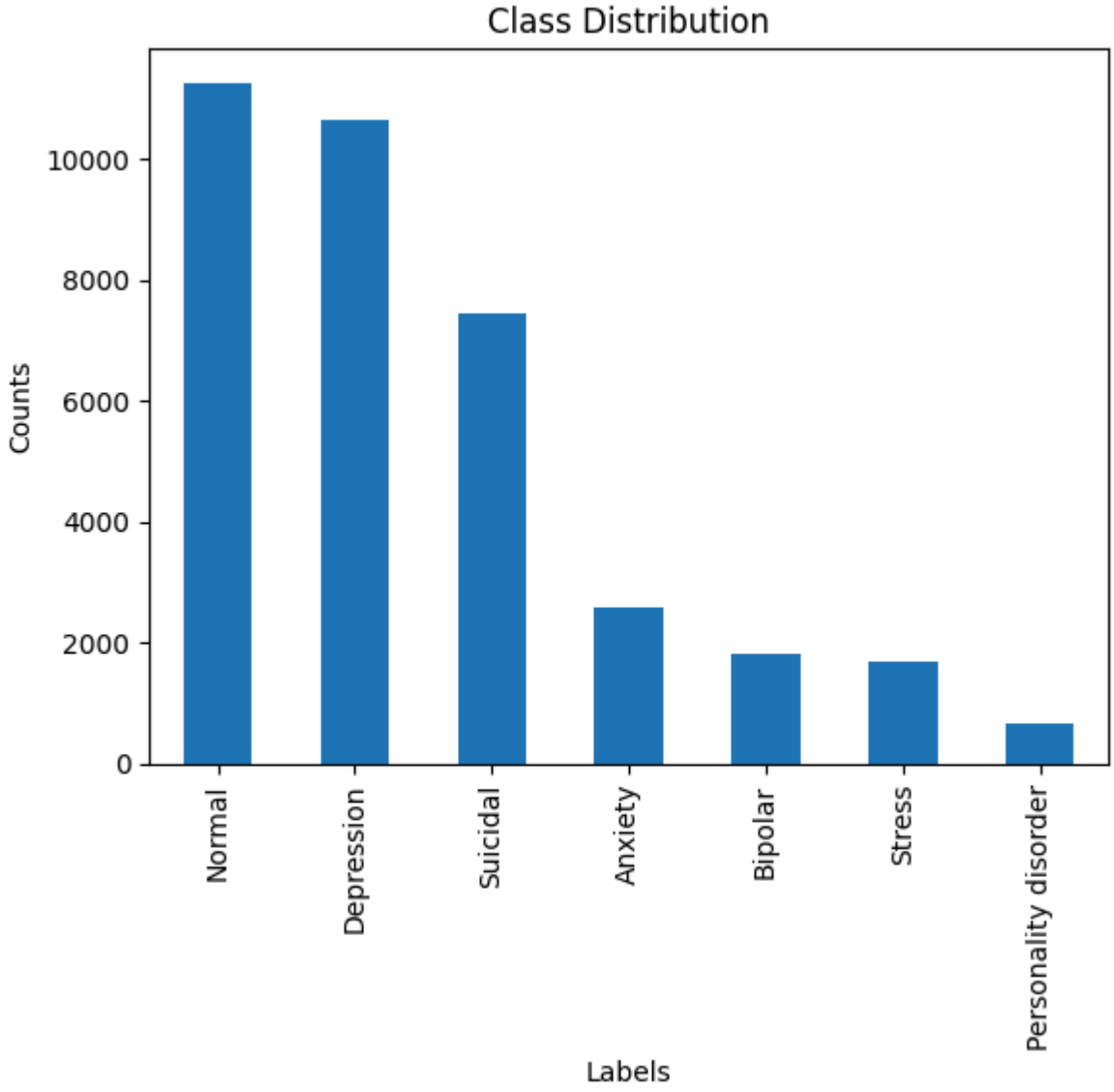
```
Dataset shape after cleaning: (36080, 2)
```

In [ ]:
```
# Check class distribution
status_counts = df['Status'].value_counts()
print("Class Distribution:\n", status_counts)
```

```
Class Distribution:
 Status
Normal                  11264
Depression              10635
Suicidal                 7452
Anxiety                  2586
Bipolar                  1801
Stress                   1680
Personality disorder      662
Name: count, dtype: int64
```

In [ ]:
```
# Plot class distribution
df['Status'].value_counts().plot(kind='bar')
plt.title("Class Distribution")
plt.xlabel("Labels")
plt.ylabel("Counts")
```

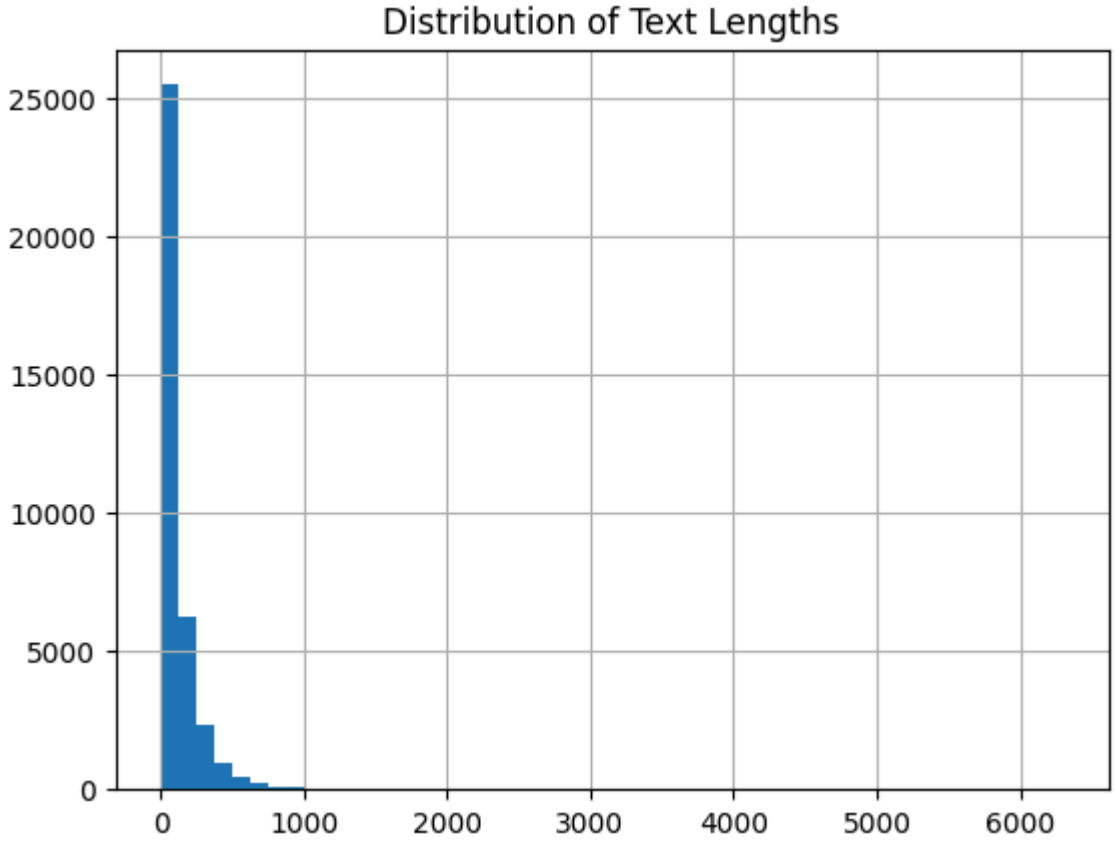
Out[ ]:
```
Text(0, 0.5, 'Counts')
```



In [ ]:
```
# Add a column for text length (in words)
df['TextLength'] = df['Statement'].apply(lambda x: len(str(x).split()))
```

In [ ]:
```
# Text length column (optional)
df['text_length'] = df['Statement'].apply(lambda x: len(str(x).split()))

# Plot histogram of text lengths
df['text_length'].hist(bins=50)
plt.title("Distribution of Text Lengths")
```

Out[ ]:
```
Text(0.5, 1.0, 'Distribution of Text Lengths')
```



In [ ]:
```
# Percentage breakdown of each class (to detect imbalance)
print("\nClass Percentages:")
print(round(df['Status'].value_counts(normalize=True) * 100, 2))
```

```
Class Percentages:
Status
Normal                  31.22
Depression              29.48
Suicidal                20.65
Anxiety                  7.17
Bipolar                  4.99
Stress                   4.66
Personality disorder     1.83
Name: proportion, dtype: float64
```

In [ ]:
```
# Total missing values per column
df.isnull().sum()
```

Out[ ]:
```
Statement      0
Status         0
TextLength     0
text_length    0
dtype: int64
```

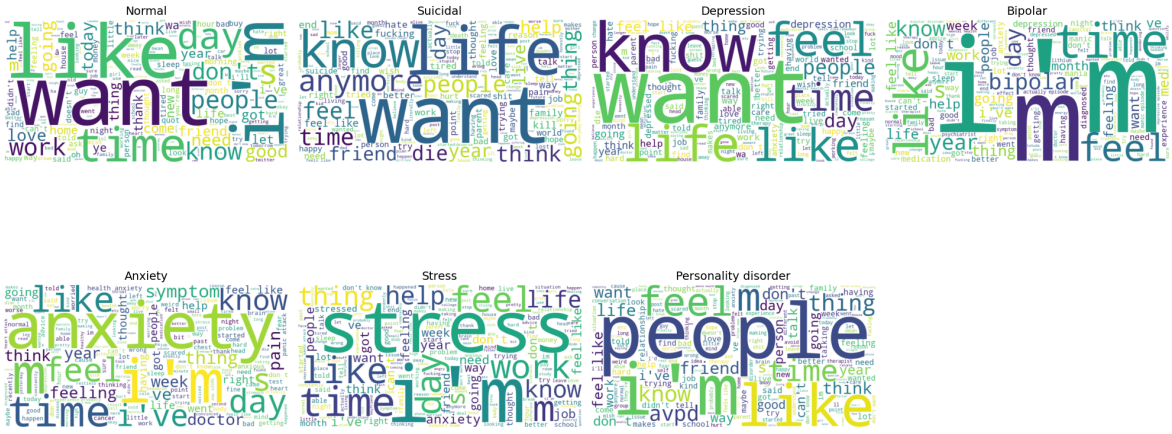
In [ ]:
```
import spacy
# Load SpaCy English model
nlp = spacy.load('en_core_web_sm')
nlp.max_length = 2_000_000

from spacy.lang.en.stop_words import STOP_WORDS
import string

def get_clean_word_freq(label):
    texts = df[df['Status'].str.strip().str.lower() == label.lower()]['St
```

```
    words = []

    for text in texts:
        doc = nlp(str(text).lower())
        for token in doc:
            if (token.text not in STOP_WORDS and
                token.is_alpha and
                not token.is_space and
                len(token.text) > 2):
                words.append(token.lemma_)  # use lemma instead of raw wo

    return Counter(words).most_common(10)

statuses = df['Status'].dropna().unique()

for status in statuses:
    print(f"\nTop words in {status}:")
    print(get_clean_word_freq(status))
```

```
Top words in Depression:
[('feel', 15835), ('like', 12916), ('want', 10250), ('know', 8693), ('lif
e', 7899), ('time', 6592), ('go', 6355), ('think', 6192), ('people', 552
6), ('thing', 5373)]

Top words in Stress:
[('feel', 1240), ('stress', 1117), ('like', 1113), ('know', 792), ('time',
734), ('work', 654), ('go', 627), ('get', 613), ('want', 578), ('day', 54
5)]

Top words in Normal:
[('want', 983), ('like', 951), ('go', 665), ('time', 642), ('know', 616),
('good', 589), ('work', 545), ('think', 533), ('day', 523), ('get', 503)]

Top words in Suicidal:
[('want', 9038), ('feel', 7511), ('like', 6614), ('life', 5569), ('know',
5429), ('think', 4351), ('go', 4261), ('time', 3580), ('anymore', 3516),
('people', 3362)]

Top words in Anxiety:
[('feel', 2879), ('anxiety', 2568), ('like', 2260), ('go', 1768), ('know',
1453), ('time', 1378), ('think', 1368), ('get', 1367), ('day', 1235), ('ba
d', 1038)]

Top words in Personality disorder:
[('like', 1101), ('feel', 1015), ('people', 749), ('know', 630), ('want',
566), ('think', 505), ('time', 451), ('friend', 413), ('thing', 410), ('li
fe', 391)]

Top words in Bipolar:
[('feel', 2379), ('like', 1973), ('know', 1410), ('bipolar', 1266), ('tim
e', 1188), ('go', 1161), ('want', 1155), ('think', 1057), ('year', 1044),
('get', 965)]
```

In [ ]:
```
# List of all your sentiment labels
statuses = [
    "Normal",
    "Suicidal",
    "Depression",
    "Bipolar",
    "Anxiety",
```

```
    "Stress",
    "Personality disorder"
]

# Create subplots: 2 rows, 4 columns
fig, axes = plt.subplots(2, 4, figsize=(20, 10))
axes = axes.flatten()

for i, label in enumerate(statuses):
    # Get all text from that label
    texts = df[df['Status'].str.strip().str.lower() == label.lower()]['St
    full_text = " ".join(texts.astype(str)).lower()

    # Generate WordCloud
    wordcloud = WordCloud(
        width=800,
        height=400,
        background_color='white',
        stopwords=STOP_WORDS,
        collocations=True
    ).generate(full_text)

    # Plot it
    axes[i].imshow(wordcloud, interpolation='bilinear')
    axes[i].axis("off")
    axes[i].set_title(f"{label}", fontsize=14)

# Hide empty subplot (8th box)
axes[-1].axis("off")

plt.tight_layout()
plt.show()
```



PROCESSSING STAGE

In [ ]:

```
def preprocess(text):
    doc = nlp(str(text).lower())
    tokens = [
        token.lemma_ for token in doc
        if token.is_alpha and
           token.text not in STOP_WORDS and
           not token.is_space and
           len(token.text) > 2
    ]
```

```
    return " ".join(tokens)

df['CleanText'] = df['Statement'].apply(preprocess)
```

In [ ]:
```
from sklearn.feature_extraction.text import TfidfVectorizer

# Initialize vectorizer
tfidf = TfidfVectorizer(max_features=5000)  # You can change this number

# Fit and transform
X_tfidf = tfidf.fit_transform(df['CleanText'])

# Convert to DataFrame
X_tfidf_df = pd.DataFrame(X_tfidf.toarray(), columns=tfidf.get_feature_na
```

In [ ]:
```
from sklearn.preprocessing import LabelEncoder

le = LabelEncoder()
y = le.fit_transform(df['Status'])
```

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

X_train, X_temp, y_train, y_temp = train_test_split(X_tfidf, y, test_size
X_val, X_test, y_val, y_test = train_test_split(X_temp, y_temp, test_size

print(f"Train size: {X_train.shape[0]} | Val: {X_val.shape[0]} | Test: {X
```

```
Train size: 28864 | Val: 3608 | Test: 3608
```

In [ ]:
```
from imblearn.over_sampling import SMOTE

smote = SMOTE(random_state=42)
X_resampled, y_resampled = smote.fit_resample(X_train, y_train)
```

LEARNING STAGE

Logistic Regression

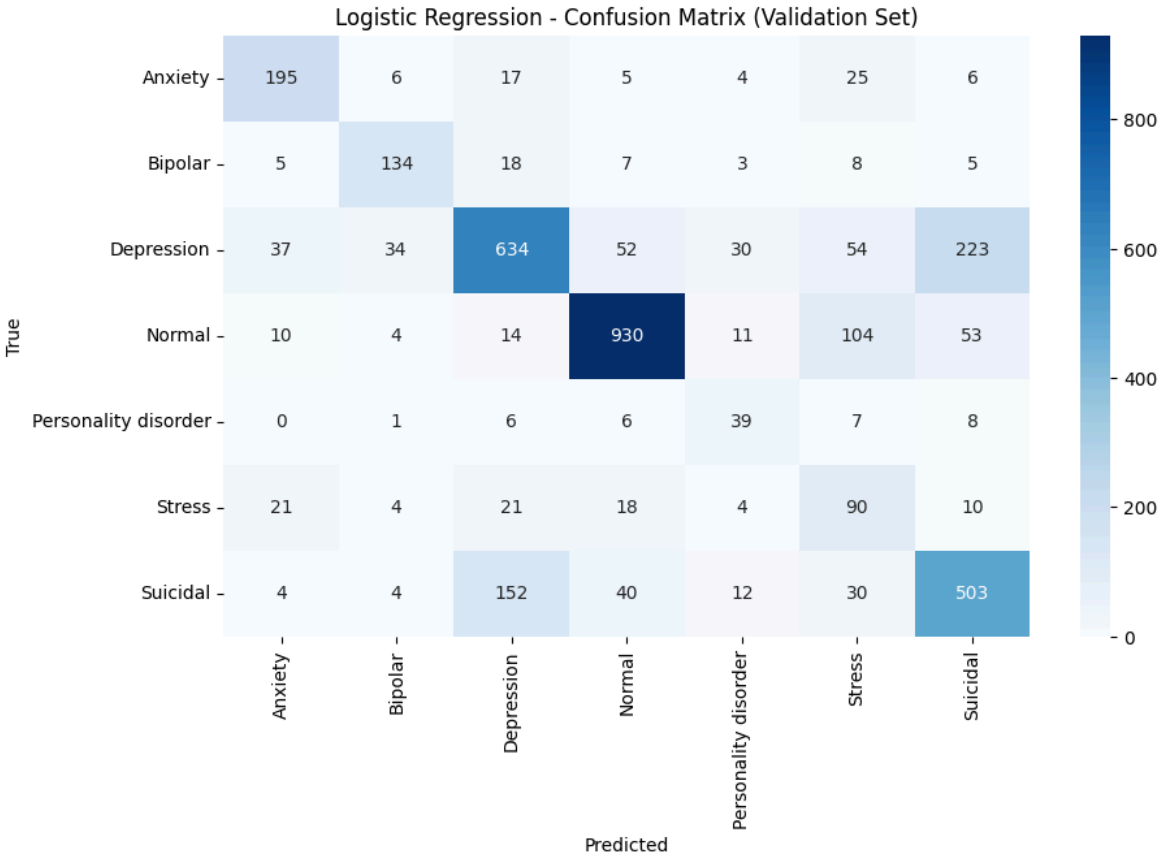
In [ ]:
```
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report, confusion_matrix, accu

# Train
lr = LogisticRegression(max_iter=1000, random_state=42)
lr.fit(X_resampled, y_resampled)
```

Out[ ]:
```
LogisticRegression
LogisticRegression(max_iter=1000, random_state=42)
```

In [ ]:
```
y_val_pred = lr.predict(X_val)

print("Validation Accuracy:", accuracy_score(y_val, y_val_pred))
print("\nClassification Report:")
print(classification_report(y_val, y_val_pred, target_names=le.classes_))
```

```
Validation Accuracy: 0.6998337028824834

Classification Report:
                     precision    recall  f1-score   support

            Anxiety       0.72      0.76      0.74       258
            Bipolar       0.72      0.74      0.73       180
         Depression       0.74      0.60      0.66      1064
             Normal       0.88      0.83      0.85      1126
Personality disorder       0.38      0.58      0.46        67
             Stress       0.28      0.54      0.37       168
           Suicidal       0.62      0.68      0.65       745

           accuracy                           0.70      3608
          macro avg       0.62      0.67      0.64      3608
       weighted avg       0.73      0.70      0.71      3608
```

In [ ]:
```python
import seaborn as sns
import matplotlib.pyplot as plt
import numpy as np

cm = confusion_matrix(y_val, y_val_pred)
plt.figure(figsize=(10, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues',
            xticklabels=le.classes_,
            yticklabels=le.classes_)
plt.xlabel("Predicted")
plt.ylabel("True")
plt.title("Logistic Regression - Confusion Matrix (Validation Set)")
plt.show()
```



Random Forest

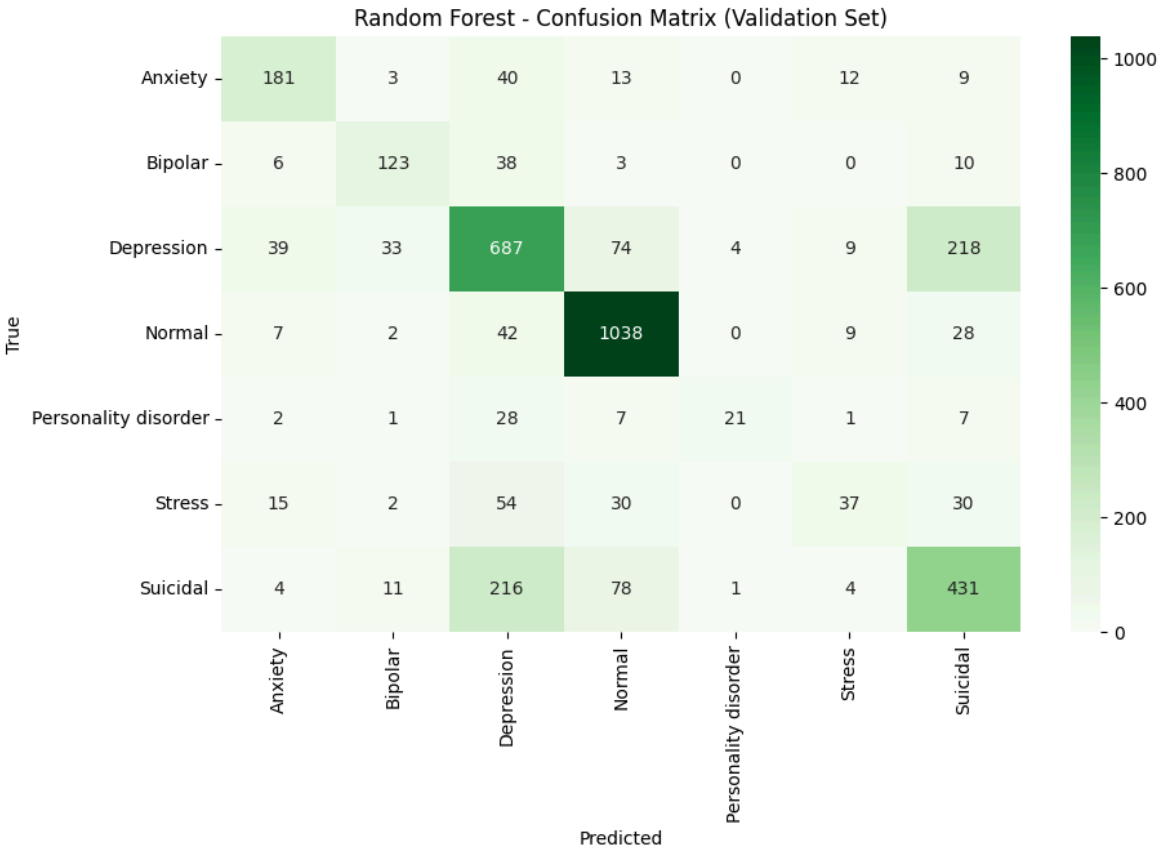
In [ ]:
```
from sklearn.ensemble import RandomForestClassifier

rf = RandomForestClassifier(n_estimators=100, random_state=42, n_jobs=-1)
rf.fit(X_resampled, y_resampled)
```

Out[ ]:
```
RandomForestClassifier(n_jobs=-1, random_state=42)
```

In [ ]:
```
y_val_pred_rf = rf.predict(X_val)

from sklearn.metrics import classification_report, confusion_matrix, accu

print("Validation Accuracy (Random Forest):", accuracy_score(y_val, y_val
print("\nClassification Report:")
print(classification_report(y_val, y_val_pred_rf, target_names=le.classes
```

```
Validation Accuracy (Random Forest): 0.6978935698447893

Classification Report:
                    precision    recall  f1-score   support

           Anxiety       0.71      0.70      0.71       258
           Bipolar       0.70      0.68      0.69       180
        Depression       0.62      0.65      0.63      1064
            Normal       0.84      0.92      0.88      1126
Personality disorder       0.81      0.31      0.45        67
            Stress       0.51      0.22      0.31       168
          Suicidal       0.59      0.58      0.58       745

          accuracy                           0.70      3608
         macro avg       0.68      0.58      0.61      3608
      weighted avg       0.69      0.70      0.69      3608
```

In [ ]:
```
import seaborn as sns
import matplotlib.pyplot as plt

cm_rf = confusion_matrix(y_val, y_val_pred_rf)

plt.figure(figsize=(10, 6))
sns.heatmap(cm_rf, annot=True, fmt='d', cmap='Greens',
            xticklabels=le.classes_,
            yticklabels=le.classes_)
plt.xlabel("Predicted")
plt.ylabel("True")
plt.title("Random Forest - Confusion Matrix (Validation Set)")
plt.show()
```



Multinomial Naive Bayes

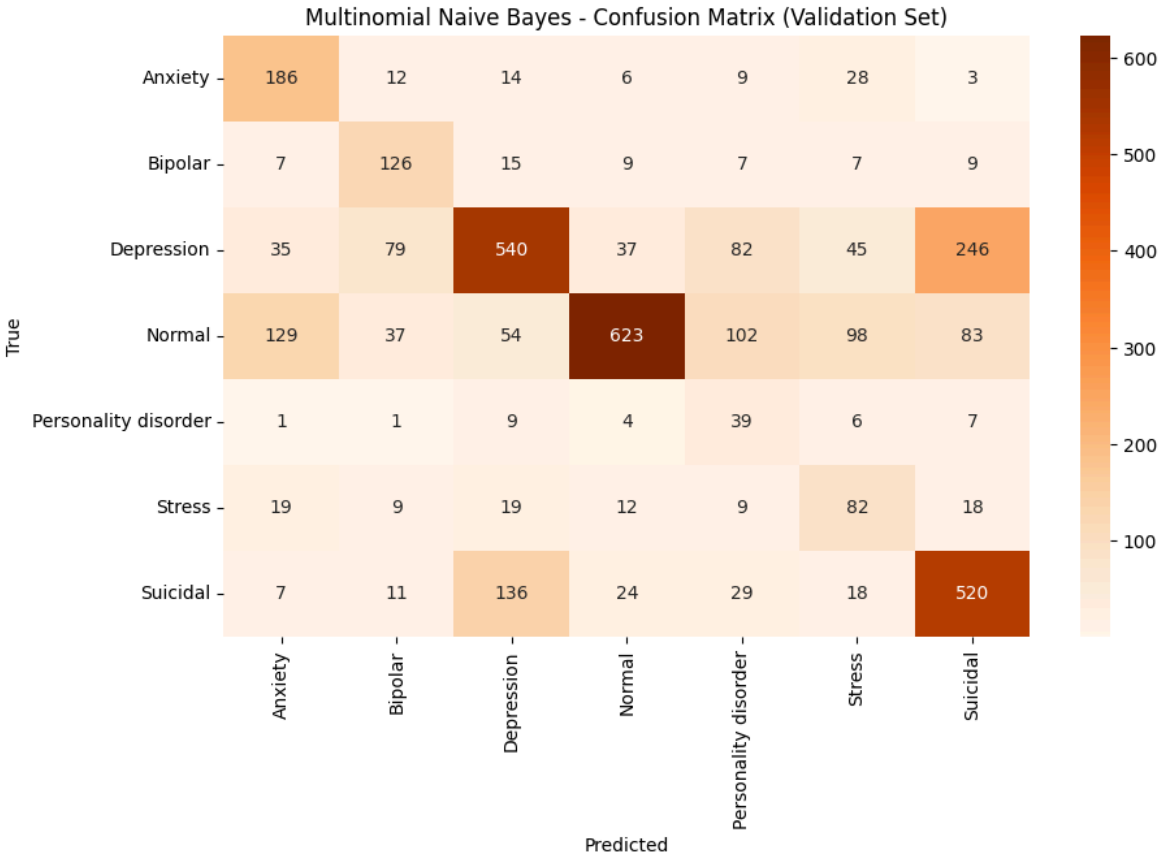
In [ ]:
```
from sklearn.naive_bayes import MultinomialNB

nb = MultinomialNB()
nb.fit(X_resampled, y_resampled)
```

Out[ ]:
```
MultinomialNB()
```

In [ ]:
```
y_val_pred_nb = nb.predict(X_val)

from sklearn.metrics import classification_report, confusion_matrix, accu

print("Validation Accuracy (Naive Bayes):", accuracy_score(y_val, y_val_p
print("\nClassification Report:")
print(classification_report(y_val, y_val_pred_nb, target_names=le.classes
```

```
Validation Accuracy (Naive Bayes): 0.5864745011086474

Classification Report:
                     precision    recall  f1-score   support

            Anxiety       0.48      0.72      0.58       258
            Bipolar       0.46      0.70      0.55       180
         Depression       0.69      0.51      0.58      1064
             Normal       0.87      0.55      0.68      1126
Personality disorder       0.14      0.58      0.23        67
             Stress       0.29      0.49      0.36       168
           Suicidal       0.59      0.70      0.64       745

           accuracy                           0.59      3608
          macro avg       0.50      0.61      0.52      3608
       weighted avg       0.67      0.59      0.61      3608
```

In [ ]:
```python
import seaborn as sns
import matplotlib.pyplot as plt

cm_nb = confusion_matrix(y_val, y_val_pred_nb)

plt.figure(figsize=(10, 6))
sns.heatmap(cm_nb, annot=True, fmt='d', cmap='Oranges',
            xticklabels=le.classes_,
            yticklabels=le.classes_)
plt.xlabel("Predicted")
plt.ylabel("True")
plt.title("Multinomial Naive Bayes - Confusion Matrix (Validation Set)")
plt.show()
```



Neural Network

In [ ]:
```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout
from tensorflow.keras.utils import to_categorical
```

In [ ]:
```
y_train_cat = to_categorical(y_resampled)
y_val_cat = to_categorical(y_val)
y_test_cat = to_categorical(y_test)
```

In [ ]:
```
model = Sequential()
model.add(Dense(512, activation='relu', input_shape=(X_resampled.shape[1]
model.add(Dropout(0.3))
model.add(Dense(256, activation='relu'))
model.add(Dropout(0.3))
model.add(Dense(y_train_cat.shape[1], activation='softmax'))  # Output la

model.compile(optimizer='adam',
              loss='categorical_crossentropy',
              metrics=['accuracy'])
```

```
/Users/alifawaz/miniconda3/lib/python3.11/site-packages/keras/src/layers/c
ore/dense.py:87: UserWarning: Do not pass an `input_shape`/`input_dim` arg
ument to a layer. When using Sequential models, prefer using an `Input(sha
pe)` object as the first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

In [ ]:
```
history = model.fit(
    X_resampled.toarray(), y_train_cat,
    epochs=10,
    batch_size=64,
    validation_data=(X_val.toarray(), y_val_cat),
    verbose=2
)
```

```
Epoch 1/10
986/986 - 10s - 10ms/step - accuracy: 0.7967 - loss: 0.5784 - val_accurac
y: 0.7275 - val_loss: 0.8674
Epoch 2/10
986/986 - 10s - 10ms/step - accuracy: 0.9151 - loss: 0.2416 - val_accurac
y: 0.7142 - val_loss: 1.0606
Epoch 3/10
986/986 - 10s - 10ms/step - accuracy: 0.9503 - loss: 0.1422 - val_accurac
y: 0.7167 - val_loss: 1.3133
Epoch 4/10
986/986 - 9s - 9ms/step - accuracy: 0.9728 - loss: 0.0848 - val_accuracy:
0.7112 - val_loss: 1.5745
Epoch 5/10
986/986 - 9s - 9ms/step - accuracy: 0.9831 - loss: 0.0561 - val_accuracy:
0.7043 - val_loss: 1.7344
Epoch 6/10
986/986 - 9s - 9ms/step - accuracy: 0.9877 - loss: 0.0429 - val_accuracy:
0.7012 - val_loss: 1.9194
Epoch 7/10
986/986 - 9s - 9ms/step - accuracy: 0.9910 - loss: 0.0340 - val_accuracy:
0.7059 - val_loss: 2.1021
Epoch 8/10
986/986 - 8s - 9ms/step - accuracy: 0.9910 - loss: 0.0318 - val_accuracy:
0.7037 - val_loss: 2.1919
Epoch 9/10
986/986 - 8s - 9ms/step - accuracy: 0.9929 - loss: 0.0265 - val_accuracy:
0.7068 - val_loss: 2.3493
Epoch 10/10
986/986 - 9s - 9ms/step - accuracy: 0.9926 - loss: 0.0263 - val_accuracy:
0.7084 - val_loss: 2.3993
```

In [ ]:

```python
from sklearn.metrics import classification_report, confusion_matrix, accu
import numpy as np

y_val_pred_nn = model.predict(X_val.toarray())
y_val_labels = np.argmax(y_val_pred_nn, axis=1)

print("Validation Accuracy (Neural Net):", accuracy_score(y_val, y_val_la
print("\nClassification Report:")
print(classification_report(y_val, y_val_labels, target_names=le.classes_
```

```
113/113 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step
Validation Accuracy (Neural Net): 0.7084257206208425

Classification Report:
                     precision    recall  f1-score   support

            Anxiety       0.73      0.68      0.71       258
            Bipolar       0.74      0.64      0.69       180
         Depression       0.63      0.69      0.66      1064
             Normal       0.87      0.90      0.88      1126
Personality disorder       0.66      0.40      0.50        67
             Stress       0.43      0.33      0.37       168
           Suicidal       0.61      0.58      0.60       745

           accuracy                           0.71      3608
          macro avg       0.67      0.60      0.63      3608
       weighted avg       0.70      0.71      0.70      3608
```

XGBoost

In [ ]:
```
import xgboost as xgb
from xgboost import XGBClassifier

xgb_model = XGBClassifier(use_label_encoder=False, eval_metric='mlogloss'
xgb_model.fit(X_resampled, y_resampled)
```

```
/Users/alifawaz/miniconda3/lib/python3.11/site-packages/xgboost/core.py:15
8: UserWarning: [17:22:58] WARNING: /Users/runner/work/xgboost/xgboost/sr
c/learner.cc:740:
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)
```

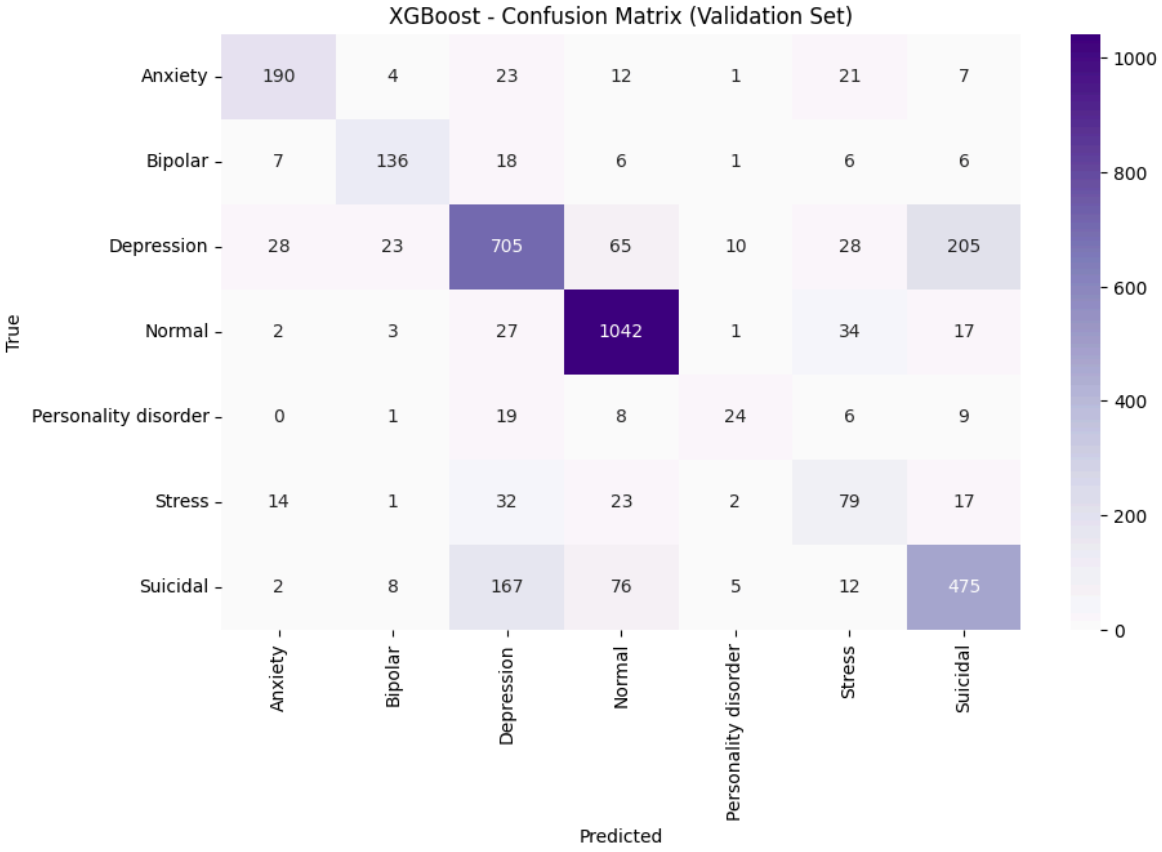
Out[ ]:
```
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=None, device=None, early_stopping_
rounds=None,
              enable_categorical=False, eval_metric='mlogloss',
              feature_types=None, gamma=None, grow_policy=None,
              importance_type=None, interaction_constraints=None,
              learning_rate=None, max_bin=None, max_cat_threshold
=None,
```

In [ ]:
```
y_val_pred_xgb = xgb_model.predict(X_val)

from sklearn.metrics import classification_report, confusion_matrix, accu

print("Validation Accuracy (XGBoost):", accuracy_score(y_val, y_val_pred_
print("\nClassification Report:")
print(classification_report(y_val, y_val_pred_xgb, target_names=le.classe
```

```
Validation Accuracy (XGBoost): 0.7347560975609756

Classification Report:
                     precision    recall  f1-score   support

            Anxiety       0.78      0.74      0.76       258
            Bipolar       0.77      0.76      0.76       180
         Depression       0.71      0.66      0.69      1064
             Normal       0.85      0.93      0.88      1126
Personality disorder       0.55      0.36      0.43        67
             Stress       0.42      0.47      0.45       168
           Suicidal       0.65      0.64      0.64       745

           accuracy                           0.73      3608
          macro avg       0.68      0.65      0.66      3608
       weighted avg       0.73      0.73      0.73      3608
```

In [ ]:
```
import seaborn as sns
import matplotlib.pyplot as plt

cm_xgb = confusion_matrix(y_val, y_val_pred_xgb)
```

```
plt.figure(figsize=(10, 6))
sns.heatmap(cm_xgb, annot=True, fmt='d', cmap='Purples',
            xticklabels=le.classes_,
            yticklabels=le.classes_)
plt.title("XGBoost - Confusion Matrix (Validation Set)")
plt.xlabel("Predicted")
plt.ylabel("True")
plt.show()
```



SAVING DATASETS

In [ ]:
```
df.to_csv("cleaned_sentiment_dataset.csv", index=False)
```

SAVING RESULTS

In [ ]:
```
import pandas as pd

results = {
    'Model': ['Logistic Regression', 'Random Forest', 'Naive Bayes', 'Neu
    'Accuracy': [0.70, 0.70, 0.59, 0.71, 0.73],
    'Macro F1': [0.64, 0.61, 0.52, 0.63, 0.66],
    'Weighted F1': [0.71, 0.69, 0.61, 0.70, 0.73]
}

summary_df = pd.DataFrame(results)
summary_df.sort_values(by='Accuracy', ascending=False, inplace=True)
summary_df.reset_index(drop=True, inplace=True)

summary_df
```

Out[ ]:

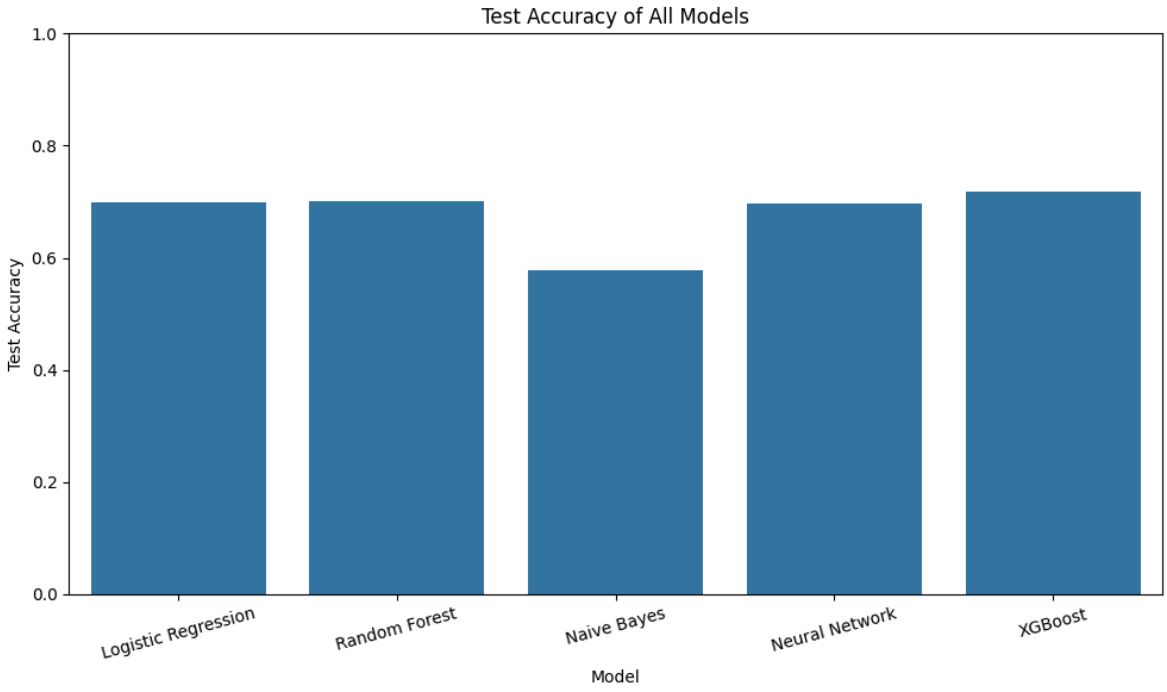
	Model	Accuracy	Macro F1	Weighted F1
0	XGBoost	0.73	0.66	0.73
1	Neural Network	0.71	0.63	0.70
2	Logistic Regression	0.70	0.64	0.71
3	Random Forest	0.70	0.61	0.69
4	Naive Bayes	0.59	0.52	0.61

TESTING

In [ ]:

```
from sklearn.metrics import classification_report, accuracy_score
import pandas as pd
import numpy as np

# Assuming the models have already been trained and are available:
# - lr (Logistic Regression)
# - rf (Random Forest)
# - nb (Naive Bayes)
# - model (Neural Network)
# - xgb_model (XGBoost)

# Predict on the test set
y_test_pred_lr = lr.predict(X_test)
y_test_pred_rf = rf.predict(X_test)
y_test_pred_nb = nb.predict(X_test)
y_test_pred_nn = np.argmax(model.predict(X_test.toarray()), axis=1)
y_test_pred_xgb = xgb_model.predict(X_test)

# Collect accuracy for each model
test_results = {
    "Model": ["Logistic Regression", "Random Forest", "Naive Bayes", "Neu
    "Test Accuracy": [
        accuracy_score(y_test, y_test_pred_lr),
        accuracy_score(y_test, y_test_pred_rf),
        accuracy_score(y_test, y_test_pred_nb),
        accuracy_score(y_test, y_test_pred_nn),
        accuracy_score(y_test, y_test_pred_xgb)
    ]
}

test_results_df = pd.DataFrame(test_results)
import seaborn as sns
import matplotlib.pyplot as plt

# Plotting the bar chart
plt.figure(figsize=(10, 6))
sns.barplot(data=test_results_df, x="Model", y="Test Accuracy")
plt.title("Test Accuracy of All Models")
plt.ylim(0, 1)
plt.xticks(rotation=15)
plt.tight_layout()
```

```
113/113 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step
```



In [ ]:
```
# Get test predictions for each model
lr_acc = accuracy_score(y_test, lr.predict(X_test))
rf_acc = accuracy_score(y_test, rf.predict(X_test))
nb_acc = accuracy_score(y_test, nb.predict(X_test))
nn_preds = model.predict(X_test.toarray())
nn_acc = accuracy_score(y_test, np.argmax(nn_preds, axis=1))
xgb_acc = accuracy_score(y_test, xgb_model.predict(X_test))

# Create the table
test_results_df = pd.DataFrame({
    "Model": ["Logistic Regression", "Random Forest", "Naive Bayes", "Neu
    "Test Accuracy": [lr_acc, rf_acc, nb_acc, nn_acc, xgb_acc]
})

# Display the table
print(test_results_df)
```

```
113/113 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step
                Model  Test Accuracy
0  Logistic Regression       0.698171
1        Random Forest       0.700942
2          Naive Bayes       0.577605
3       Neural Network       0.695953
4              XGBoost       0.718958
```

In [ ]:
```
import joblib

joblib.dump(xgb_model, "xgb_model.pkl")
joblib.dump(tfidf, "tfidf_vectorizer.pkl")
```

Out[ ]:
```
['tfidf_vectorizer.pkl']
```