Digital Assignment

Autism Prediction Using Different Algorithms

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Importing Libraries

In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier, plot_tree
from sklearn.ensemble import BaggingClassifier, RandomForestClassifier, GradientBoostingClassifier, AdaBoostClassifier

from sklearn.preprocessing import LabelEncoder, MinMaxScaler
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report
```

In [2]:
```
data = pd.read_csv('autism_train.csv')
data.head()
```

Out[2]:

	ID	A1_Score	A2_Score	A3_Score	A4_Score	A5_Score	A6_Score	A7_Score	A8_Score	A9_Score	...	gender	ethnicity	jaundice	aus
0	1	1	0	1	0	1	0	1	0	1	...	f	?	no	
1	2	0	0	0	0	0	0	0	0	0	...	m	?	no	
2	3	1	1	1	1	1	1	1	1	1	...	m	White-European	no	
3	4	0	0	0	0	0	0	0	0	0	...	f	?	no	
4	5	0	0	0	0	0	0	0	0	0	...	m	?	no	

5 rows × 22 columns

In [3]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 800 entries, 0 to 799
Data columns (total 22 columns):
 #   Column           Non-Null Count  Dtype  
---  ------           --------------  -----  
 0   ID               800 non-null    int64  
 1   A1_Score         800 non-null    int64  
 2   A2_Score         800 non-null    int64  
 3   A3_Score         800 non-null    int64  
 4   A4_Score         800 non-null    int64  
 5   A5_Score         800 non-null    int64  
 6   A6_Score         800 non-null    int64  
 7   A7_Score         800 non-null    int64  
 8   A8_Score         800 non-null    int64  
 9   A9_Score         800 non-null    int64  
 10  A10_Score        800 non-null    int64  
 11  age              800 non-null    float64
 12  gender           800 non-null    object 
 13  ethnicity        800 non-null    object 
 14  jaundice         800 non-null    object 
 15  austim           800 non-null    object 
 16  contry_of_res    800 non-null    object 
 17  used_app_before  800 non-null    object 
 18  result           800 non-null    float64
 19  age_desc         800 non-null    object 
 20  relation         800 non-null    object 
 21  Class/ASD        800 non-null    int64  
dtypes: float64(2), int64(12), object(8)
memory usage: 137.6+ KB
```

Data Preprocessing

In [4]:
```
data['age'] = data['age'].astype('int64')
data['age'].info()
```

```
<class 'pandas.core.series.Series'>
RangeIndex: 800 entries, 0 to 799
Series name: age
Non-Null Count  Dtype
--------------  -----
800 non-null    int64
dtypes: int64(1)
memory usage: 6.4 KB
```

In [5]:
```
data.columns
```

Out[5]:
```
Index(['ID', 'A1_Score', 'A2_Score', 'A3_Score', 'A4_Score', 'A5_Score',
       'A6_Score', 'A7_Score', 'A8_Score', 'A9_Score', 'A10_Score', 'age',
       'gender', 'ethnicity', 'jaundice', 'austim', 'contry_of_res',
       'used_app_before', 'result', 'age_desc', 'relation', 'Class/ASD'],
      dtype='object')
```

Binary Type Columns

In [6]:
```
for col in ['gender', 'jaundice', 'austim', 'used_app_before']:
    print(f"{col} --- has {len(data[col].unique())} unique values.")
    for i in data[col].unique():
        print(f"\n{i}")

    print("-"*40)
```

```
gender --- has 2 unique values.

f

m
----------------------------------------
jaundice --- has 2 unique values.

no

yes
----------------------------------------
austim --- has 2 unique values.

no

yes
----------------------------------------
used_app_before --- has 2 unique values.

no

yes
----------------------------------------
```

In [7]:
```
encoder = LabelEncoder()
for col in ['gender', 'jaundice', 'austim', 'used_app_before']:
    data[col] = encoder.fit_transform(data[col])
    print(f"{col} ---- label encoding --- Done")
```

```
gender ---- label encoding --- Done
jaundice ---- label encoding --- Done
austim ---- label encoding --- Done
used_app_before ---- label encoding --- Done
```

In [8]:
```
data[['gender', 'jaundice', 'austim', 'used_app_before']].head()
```

Out[8]:

	gender	jaundice	austim	used_app_before
0	0	0	0	0
1	1	0	0	0
2	1	0	1	0
3	0	0	0	0
4	1	0	0	0

Countries

In [9]:
```
data["contry_of_res"].unique()
```

Out[9]:
```
array(['Austria', 'India', 'United States', 'South Africa', 'Jordan',
       'United Kingdom', 'Brazil', 'New Zealand', 'Canada', 'Kazakhstan',
       'United Arab Emirates', 'Australia', 'Ukraine', 'Iraq', 'France',
       'Malaysia', 'Viet Nam', 'Egypt', 'Netherlands', 'Afghanistan',
       'Oman', 'Italy', 'AmericanSamoa', 'Bahamas', 'Saudi Arabia',
       'Ireland', 'Aruba', 'Sri Lanka', 'Russia', 'Bolivia', 'Azerbaijan',
       'Armenia', 'Serbia', 'Ethiopia', 'Sweden', 'Iceland', 'Hong Kong',
       'Angola', 'China', 'Germany', 'Spain', 'Tonga', 'Pakistan', 'Iran',
       'Argentina', 'Japan', 'Mexico', 'Nicaragua', 'Sierra Leone',
       'Czech Republic', 'Niger', 'Romania', 'Cyprus', 'Belgium',
       'Burundi', 'Bangladesh'], dtype=object)
```

In [10]:
```
# replace redundant countries
mapping = {
    "Viet Nam": "Vietnam",
    "AmericanSamoa":"United States",
    "Hong Kong": "China"
}

data["contry_of_res"] = data["contry_of_res"].replace(mapping)
```

In [11]:
```
data["contry_of_res"] = encoder.fit_transform(data["contry_of_res"])
print(f"{"contry_of_res"} ---- label encoding --- Done")
```

```
data["contry_of_res"]
```

```
contry_of_res ---- label encoding --- Done
```

Out[11]:
```
0       6
1      23
2      52
3      52
4      44
       ..
795    34
796    16
797    34
798    14
799    50
Name: contry_of_res, Length: 800, dtype: int64
```

Dropping columns

In [12]:
```
data = data.drop(["ID", "age_desc", "ethnicity"], axis = 1)
data.shape
```

Out[12]:
```
(800, 19)
```

In [13]:
```
data.relation = data.relation.replace(
    {"?": "Others",
     "Relative": "Others",
     "Parent": "Others",
     "Health care professional": "Others"}
)
```

In [14]:
```
data["relation"] = encoder.fit_transform(data["relation"])
print(f"{"relation"} ---- label encoding --- Done")

data["relation"].unique()
```

```
relation ---- label encoding --- Done
```

Out[14]:
```
array([1, 0])
```

In [15]:
```python
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 800 entries, 0 to 799
Data columns (total 19 columns):
 #   Column           Non-Null Count  Dtype  
---  ------           --------------  -----  
 0   A1_Score         800 non-null    int64  
 1   A2_Score         800 non-null    int64  
 2   A3_Score         800 non-null    int64  
 3   A4_Score         800 non-null    int64  
 4   A5_Score         800 non-null    int64  
 5   A6_Score         800 non-null    int64  
 6   A7_Score         800 non-null    int64  
 7   A8_Score         800 non-null    int64  
 8   A9_Score         800 non-null    int64  
 9   A10_Score        800 non-null    int64  
 10  age              800 non-null    int64  
 11  gender           800 non-null    int64  
 12  jaundice         800 non-null    int64  
 13  austim           800 non-null    int64  
 14  contry_of_res    800 non-null    int64  
 15  used_app_before  800 non-null    int64  
 16  result           800 non-null    float64
 17  relation         800 non-null    int64  
 18  Class/ASD        800 non-null    int64  
dtypes: float64(1), int64(18)
memory usage: 118.9 KB
```

Data Visualizations

In [16]:
```python
sns.set_theme(style="darkgrid")
```

In [17]:
```python
data.columns
```

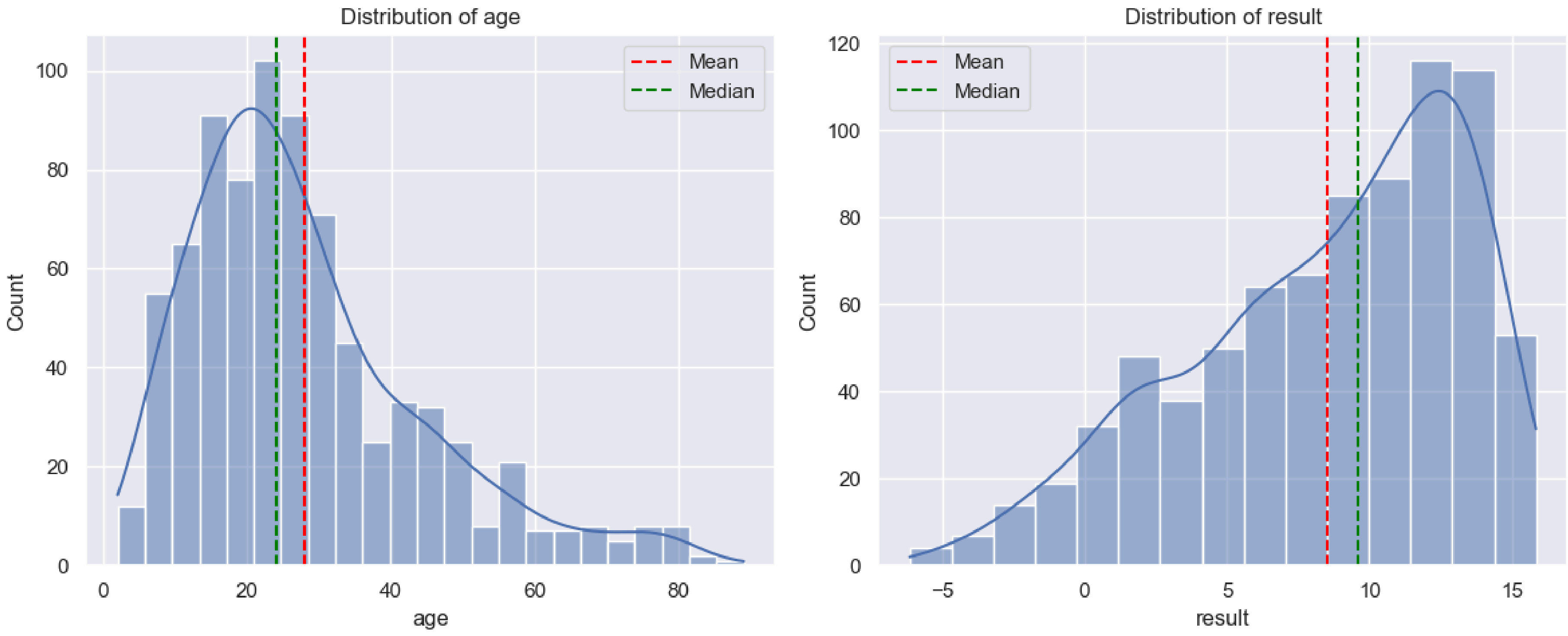
Out[17]:
```
Index(['A1_Score', 'A2_Score', 'A3_Score', 'A4_Score', 'A5_Score', 'A6_Score',
       'A7_Score', 'A8_Score', 'A9_Score', 'A10_Score', 'age', 'gender',
       'jaundice', 'austim', 'contry_of_res', 'used_app_before', 'result',
       'relation', 'Class/ASD'],
      dtype='object')
```

In [18]:
```
data.describe()
```

Out[18]:

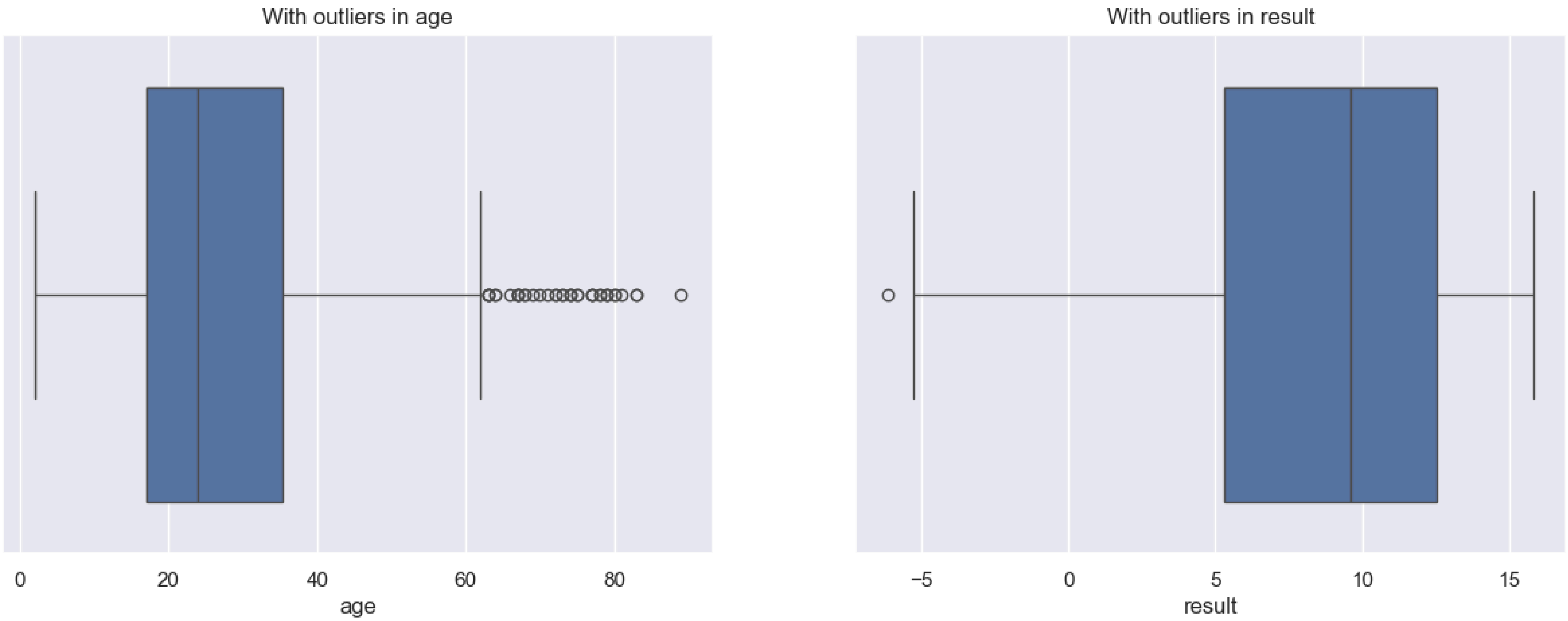
	A1_Score	A2_Score	A3_Score	A4_Score	A5_Score	A6_Score	A7_Score	A8_Score	A9_Score	A10_Score	age
count	800.000000	800.000000	800.000000	800.00000	800.000000	800.000000	800.000000	800.000000	800.000000	800.000000	800.000000
mean	0.560000	0.530000	0.450000	0.41500	0.395000	0.303750	0.397500	0.508750	0.495000	0.617500	27.963750
std	0.496697	0.499411	0.497805	0.49303	0.489157	0.460164	0.489687	0.500236	0.500288	0.486302	16.329827
min	0.000000	0.000000	0.000000	0.00000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	2.000000
25%	0.000000	0.000000	0.000000	0.00000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	17.000000
50%	1.000000	1.000000	0.000000	0.00000	0.000000	0.000000	0.000000	1.000000	0.000000	1.000000	24.000000
75%	1.000000	1.000000	1.000000	1.00000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	35.250000
max	1.000000	1.000000	1.000000	1.00000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	89.000000

In [19]:
```
fig, ax = plt.subplots(1, 2, figsize=(12, 5))

for i, col in enumerate(['age', 'result']):
    sns.histplot(data[col], kde=True, ax=ax[i])
    ax[i].axvline(data[col].mean(), color="red", linestyle="--", label="Mean")
    ax[i].axvline(data[col].median(), color="green", linestyle="--", label="Median")
    ax[i].set_title(f"Distribution of {col}")
    ax[i].legend()  # Put legend in each subplot

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



Outliers Detection

In [20]:
```
fig, axs = plt.subplots(1,2, figsize=(15, 5))
sns.boxplot(x=data.age, ax=axs[0])
axs[0].set_title("With outliers in age")

sns.boxplot(x=data.result, ax=axs[1])
axs[1].set_title("With outliers in result")

plt.show()
```

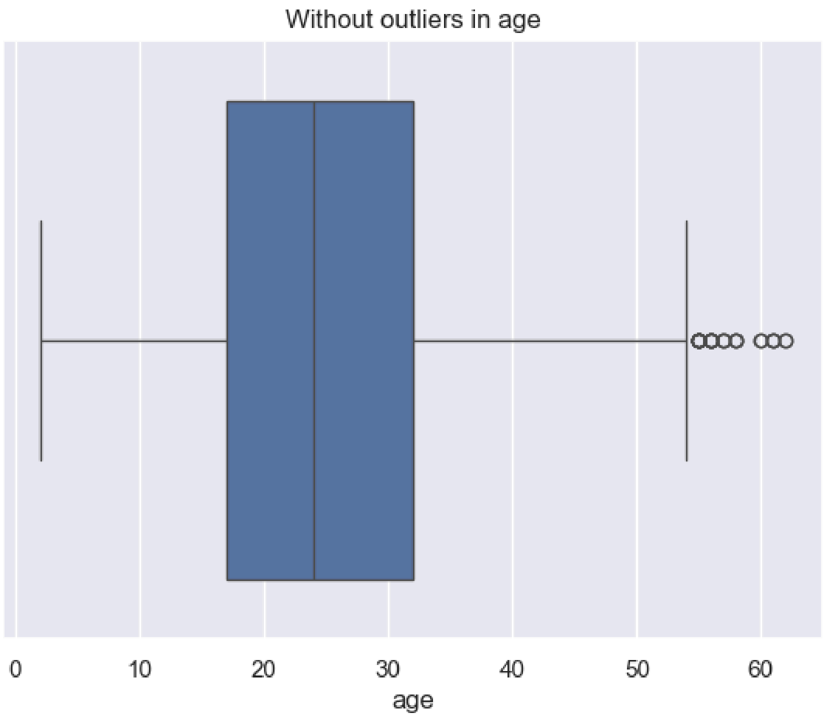


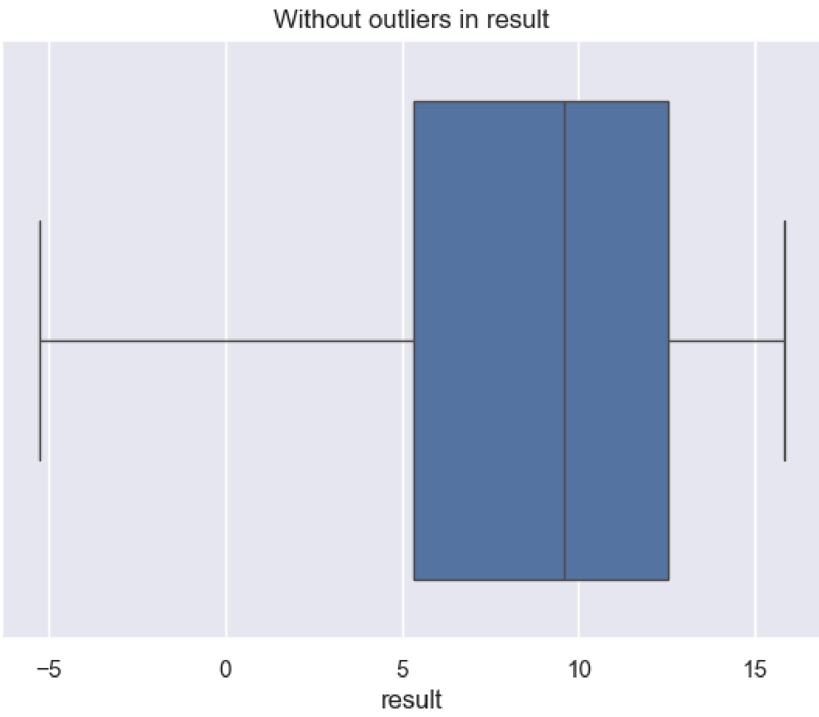
In [21]:
```
Q1 = data.age.quantile(0.25)
Q3 = data.age.quantile(0.75)

IQR = Q3 - Q1

lb = Q1 - 1.5*IQR
ub = Q3 + 1.5*IQR

age_outliers = data[(data.age < lb) | (data.age > ub)]
len(age_outliers)
```

Out[21]: 39

In [22]:
```
def replace_outliers(df, col):
    Q1 = df[col].quantile(0.25)
    Q3 = df[col].quantile(0.75)
    IQR = Q3 - Q1
```

```
    lower_bound = Q1 - 1.5 * IQR
    upper_bound = Q3 + 1.5 * IQR

    median = df[col].median()

    # replace outliers with median
    df[col] = df[col].apply(lambda x: median if x < lower_bound or x > upper_bound else x)

    return df

for i in ['age', 'result']:
    data = replace_outliers(data, i)

fig, axs = plt.subplots(1,2, figsize=(15, 5))
sns.boxplot(x=data.age, ax=axs[0])
axs[0].set_title("Without outliers in age")

sns.boxplot(x=data.result, ax=axs[1])
axs[1].set_title("Without outliers in result")

plt.show()
```





Normalize Data

In [23]:
```
scaler = MinMaxScaler()
scaled_data = scaler.fit_transform(data)
data = pd.DataFrame(scaled_data, columns=data.columns)
data.head()
```

Out[23]:

	A1_Score	A2_Score	A3_Score	A4_Score	A5_Score	A6_Score	A7_Score	A8_Score	A9_Score	A10_Score	age	gender	jaundice
0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	0.600000	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.750000	1.0	0.0
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.083333	1.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.350000	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.683333	1.0	0.0

Split the Dataset

In [24]:

```
X = data.drop(['Class/ASD'], axis=1)
y = data['Class/ASD']
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)
```

In [25]:

```
print(f"X_train shape: {X_train.shape}")
print(f"X_test shape: {X_test.shape}")
print(f"y_train shape: {y_train.shape}")
print(f"y_test shape: {y_test.shape}")
```

```
X_train shape: (640, 18)
X_test shape: (160, 18)
y_train shape: (640,)
y_test shape: (160,)
```

Logistic Regression

In [26]:

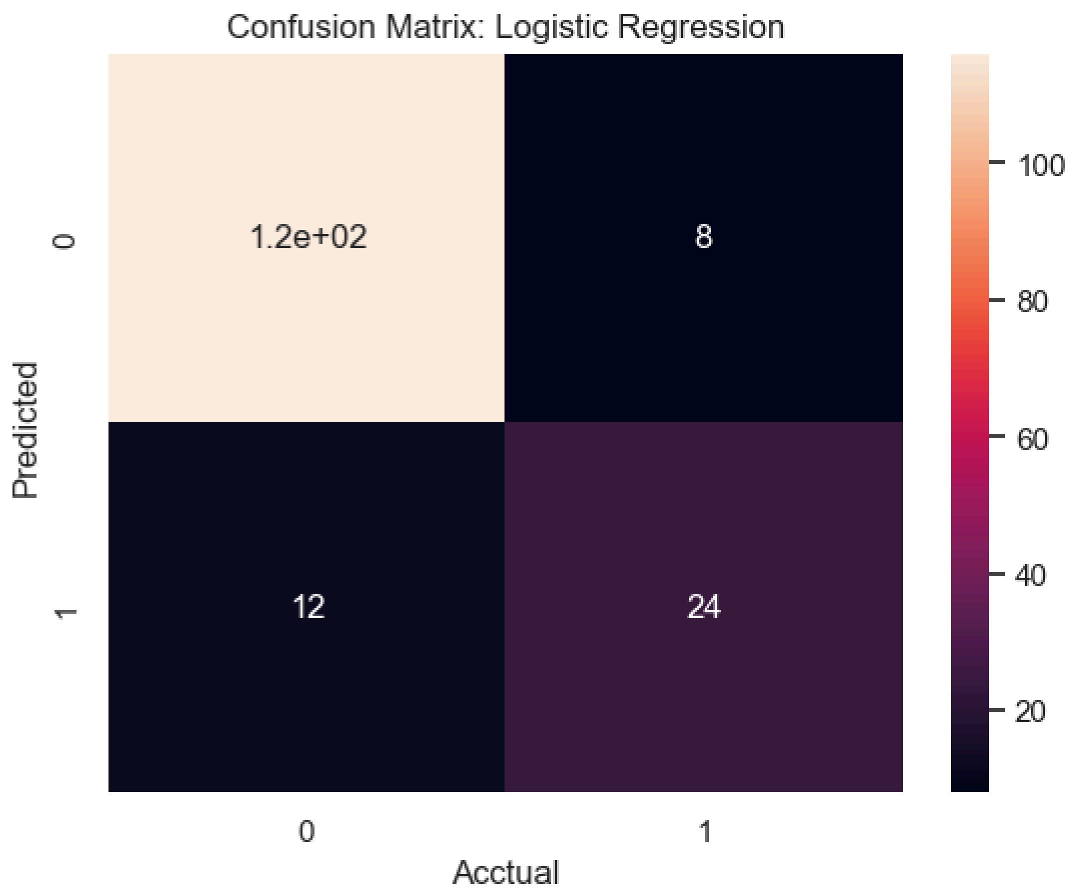
```
LR = LogisticRegression()
LR.fit(X_train, y_train)
LR_predict = LR.predict(X_test)
print(f"Logistic Regression accuracy: {accuracy_score(y_test,LR_predict)}")
```

```
Logistic Regression accuracy: 0.875
```

In [27]:
```
print(classification_report(y_test, LR_predict))
```

```
              precision    recall  f1-score   support

         0.0       0.91      0.94      0.92       124
         1.0       0.75      0.67      0.71        36

    accuracy                           0.88       160
   macro avg       0.83      0.80      0.81       160
weighted avg       0.87      0.88      0.87       160
```

In [28]:
```
LR_cfm = confusion_matrix(y_test, LR_predict)
sns.heatmap(LR_cfm, annot=True)
plt.xlabel('Acctual')
plt.ylabel('Predicted')
plt.title("Confusion Matrix: Logistic Regression")
plt.show()
```



Decision Tree Classifier

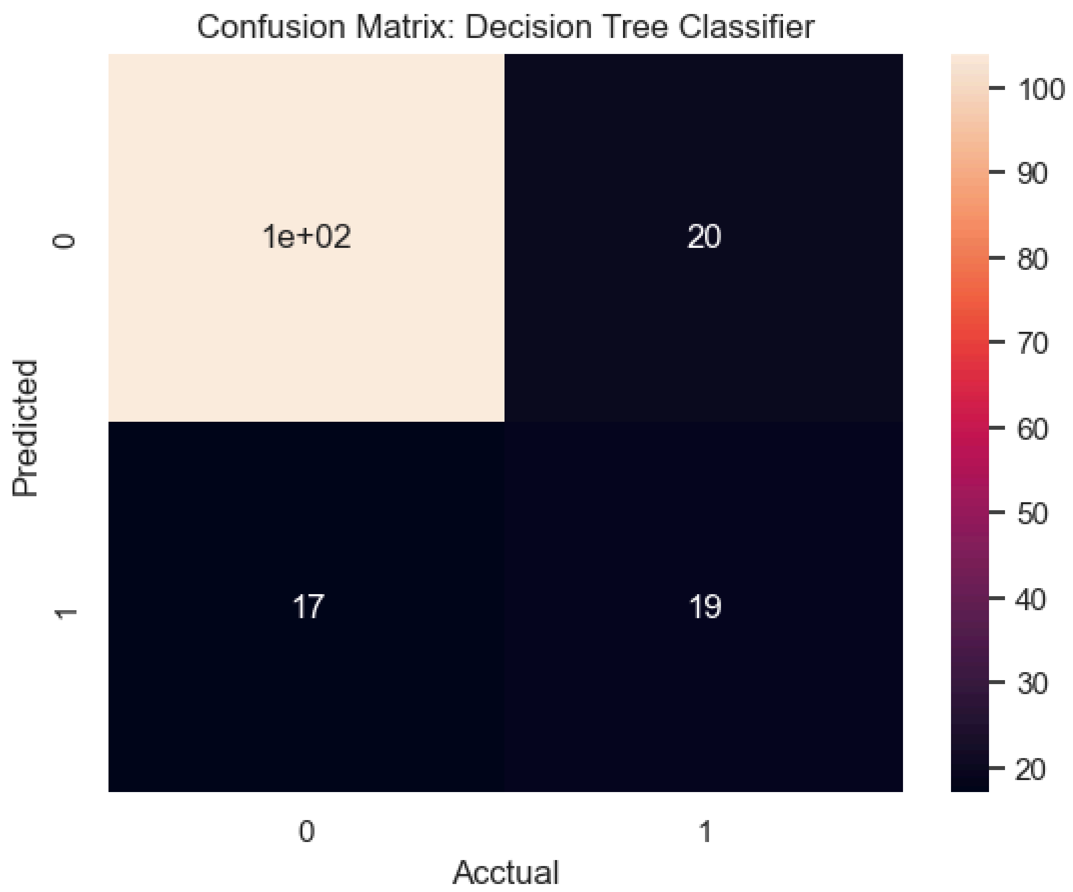
In [29]:
```
DT = DecisionTreeClassifier()
DT.fit(X_train, y_train)
DT_predict = DT.predict(X_test)
print(f"Decison Tree Classifier accuracy: {accuracy_score(y_test,DT_predict)}")
```

```
Decison Tree Classifier accuracy: 0.76875
```

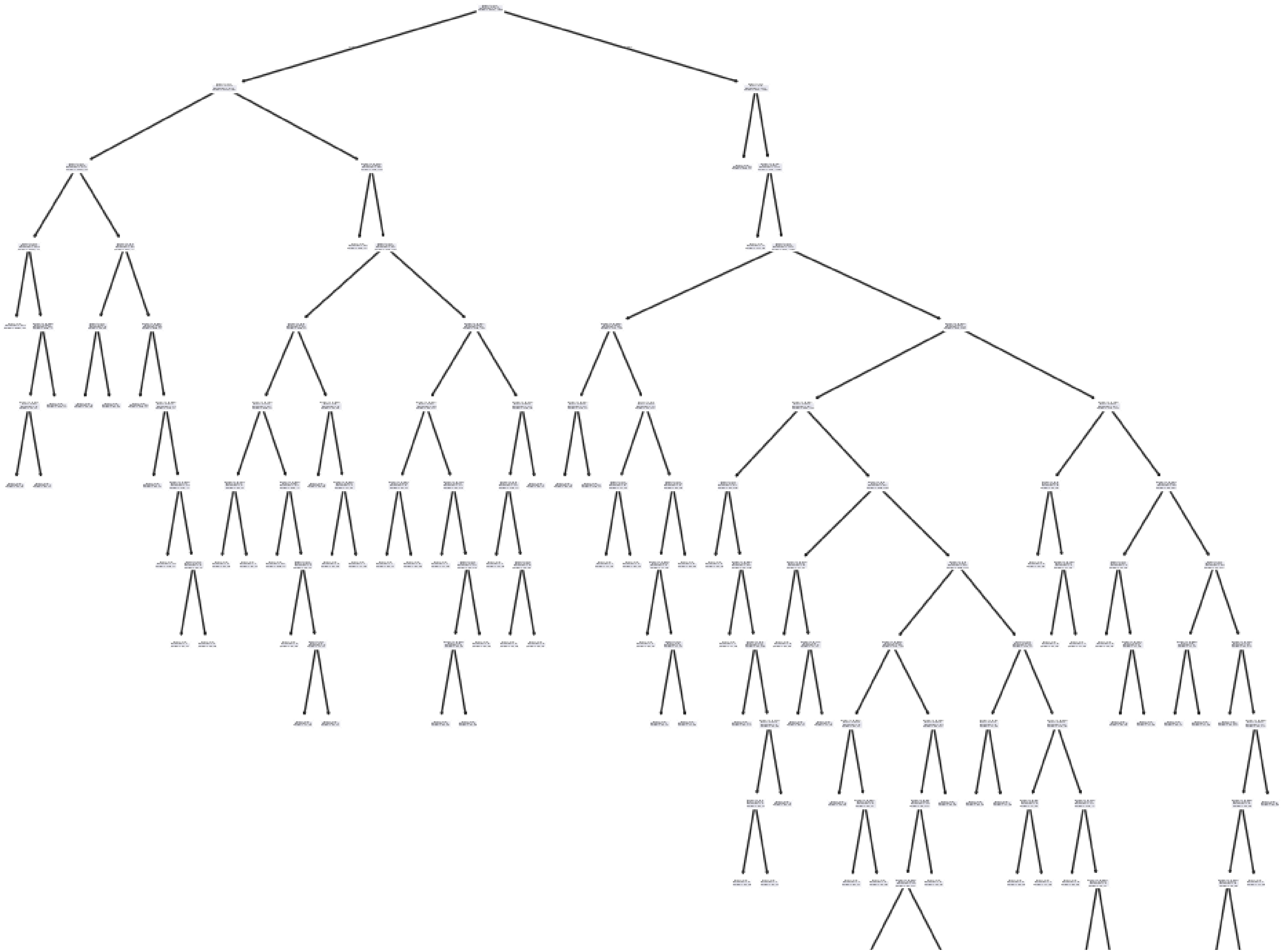
In [30]:
```
print(classification_report(y_test, DT_predict))
```

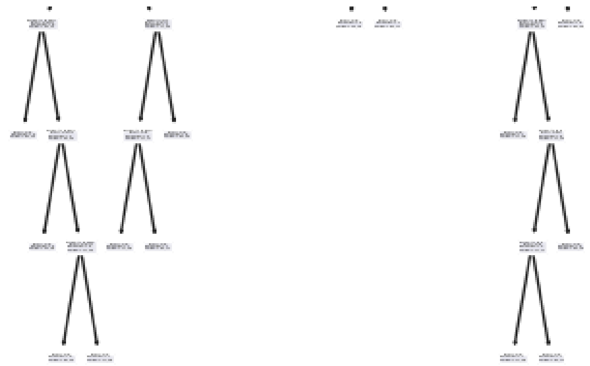
```
              precision    recall  f1-score   support

         0.0       0.86      0.84      0.85       124
         1.0       0.49      0.53      0.51        36

    accuracy                           0.77       160
   macro avg       0.67      0.68      0.68       160
weighted avg       0.78      0.77      0.77       160
```

In [31]:
```python
DT_cfm = confusion_matrix(y_test, DT_predict)
sns.heatmap(DT_cfm, annot=True)
plt.xlabel('Acctual')
plt.ylabel('Predicted')
plt.title("Confusion Matrix: Decision Tree Classifier")
plt.show()
```



In [32]:
```
plt.figure(figsize=(12, 12))
plot_tree(DT)
plt.show()
```





Bagging Classifier

In [33]:
```
bc_param_grid = {
 'n_estimators':[ 10, 50, 80 ,100, 150, 200, 250, 300]
 }

bc_base_model = BaggingClassifier(random_state=0)
bc_gs = GridSearchCV(estimator = bc_base_model, param_grid = bc_param_grid,cv=5, n_jobs = -1)
bc_gs.fit(X_train, y_train)
print(f'Best parameters for "Bagging Classifier": {bc_gs.best_params_}')
print(f'Best Accuracy: {bc_gs.best_score_}')
```

```
Best parameters for "Bagging Classifier": {'n_estimators': 10}
Best Accuracy: 0.8609375
```

Training with Optimized parameters

In [34]:
```
BC = BaggingClassifier(n_estimators = 10, random_state=0)
BC.fit(X_train, y_train)
BC_predict = BC.predict(X_test)
print(f"Bagging Classifier accuracy: {accuracy_score(y_test,BC_predict)}")
```

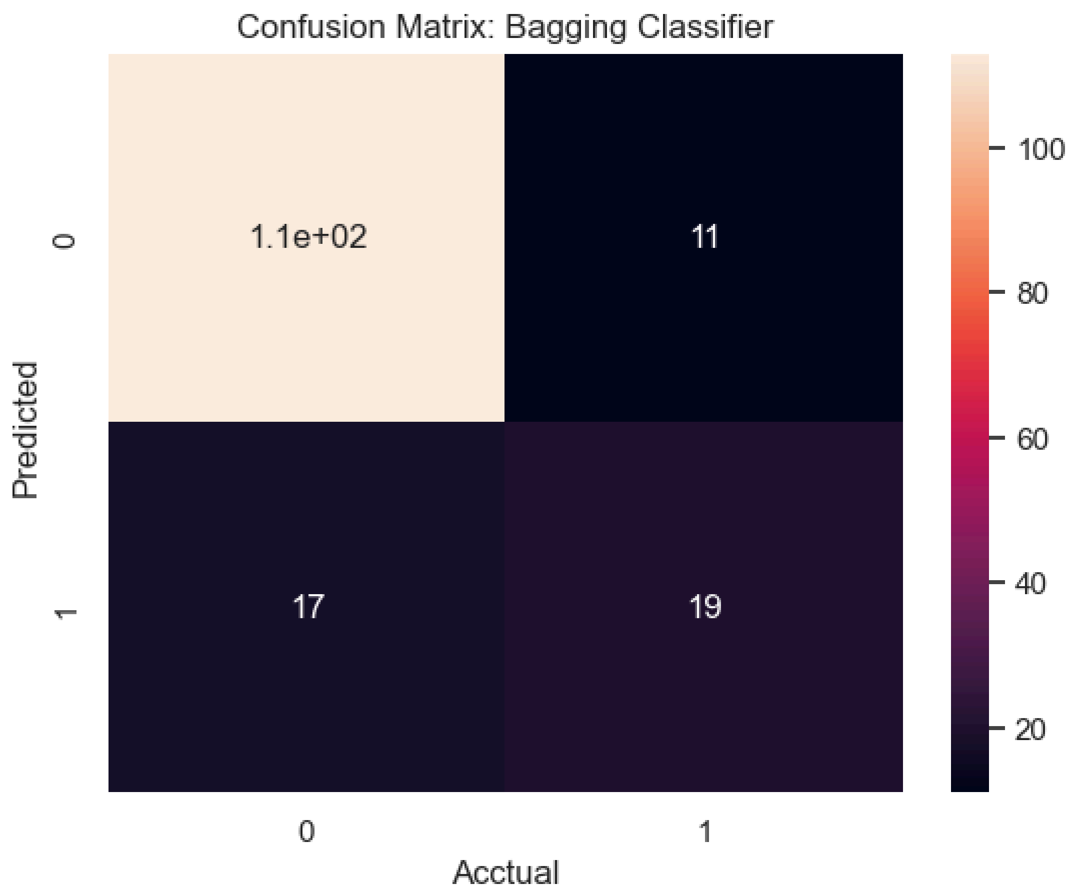
```
Bagging Classifier accuracy: 0.825
```

In [35]:
```
print(classification_report(y_test, BC_predict))
```

```
              precision    recall  f1-score   support

         0.0       0.87      0.91      0.89       124
         1.0       0.63      0.53      0.58        36

    accuracy                           0.82       160
   macro avg       0.75      0.72      0.73       160
weighted avg       0.82      0.82      0.82       160
```

In [36]:

```
BC_cfm = confusion_matrix(y_test, BC_predict)
sns.heatmap(BC_cfm, annot=True)
plt.xlabel('Acctual')
plt.ylabel('Predicted')
plt.title("Confusion Matrix: Bagging Classifier")
plt.show()
```



RandomForest Classifier

In [37]:

```
rfc_base_model = RandomForestClassifier(max_features='sqrt')
rfc_param_grid = {
        'n_estimators':[ 10, 50, 80 ,100, 150, 200, 250, 300],
        'max_depth': [1,2,3,4,10,15,20]
    }
rfc_gs = GridSearchCV(estimator = rfc_base_model, param_grid = rfc_param_grid,cv=5, n_jobs = -1)
rfc_gs.fit(X_train, y_train)
```

```
print(f'Best parameters for "Random Forest Classifier": {rfc_gs.best_params_}')
print(f'Best Accuracy: {rfc_gs.best_score_}')
```

```
Best parameters for "Random Forest Classifier": {'max_depth': 15, 'n_estimators': 100}
Best Accuracy: 0.8703125
```

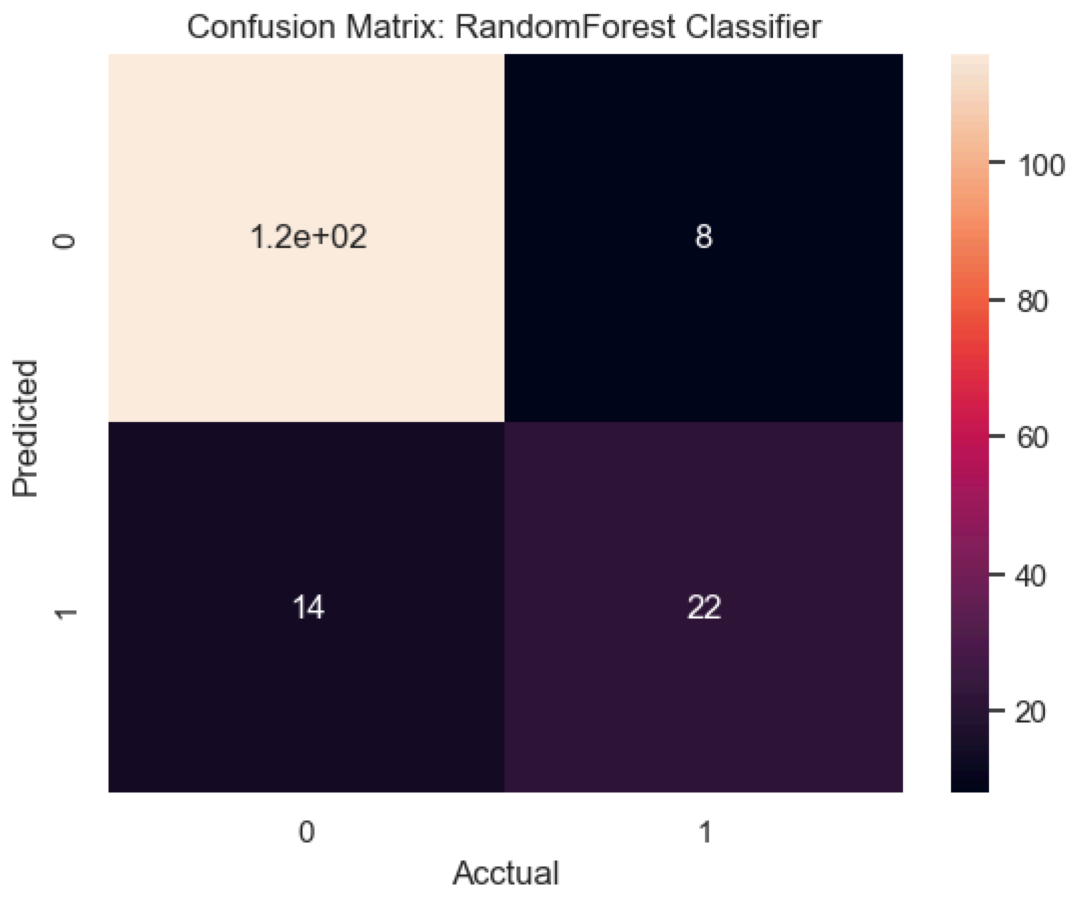
In [38]:
```
RF = RandomForestClassifier(max_features='sqrt', n_estimators=100, max_depth=15)
RF.fit(X_train, y_train)
RF_predict = RF.predict(X_test)
print(f"RandomForest Classifier accuracy: {accuracy_score(y_test,RF_predict)}")
```

```
RandomForest Classifier accuracy: 0.8625
```

In [39]:
```
print(classification_report(y_test, RF_predict))
```

```
              precision    recall  f1-score   support

         0.0       0.89      0.94      0.91       124
         1.0       0.73      0.61      0.67        36

    accuracy                           0.86       160
   macro avg       0.81      0.77      0.79       160
weighted avg       0.86      0.86      0.86       160
```

In [40]:
```
RF_cfm = confusion_matrix(y_test, RF_predict)
sns.heatmap(RF_cfm, annot=True)
plt.xlabel('Acctual')
plt.ylabel('Predicted')
plt.title("Confusion Matrix: RandomForest Classifier")
plt.show()
```



GradientBoosting Classifier

In [41]:
```
gbr_base_model =  GradientBoostingClassifier(random_state=0)
gbr_param_grid = {
        'n_estimators':[ 10, 50, 80 ,100, 150, 200, 250, 300],
        'max_depth': [1,2,3,4,10,15,20],
        'learning_rate': [0.01,0.02,0.1,0.05,0.5,0.07,0.9]
    }
gbr_gs = GridSearchCV(estimator = gbr_base_model, param_grid = gbr_param_grid,cv=5, n_jobs = -1)
gbr_gs.fit(X_train, y_train)
```

```
print(f'Best parameters for "Gradient Boosting Classifier": {gbr_gs.best_params_}')
print(f'Best Accuracy: {gbr_gs.best_score_}')
```

```
Best parameters for "Gradient Boosting Classifier": {'learning_rate': 0.1, 'max_depth': 1, 'n_estimators': 200}
Best Accuracy: 0.8609375
```

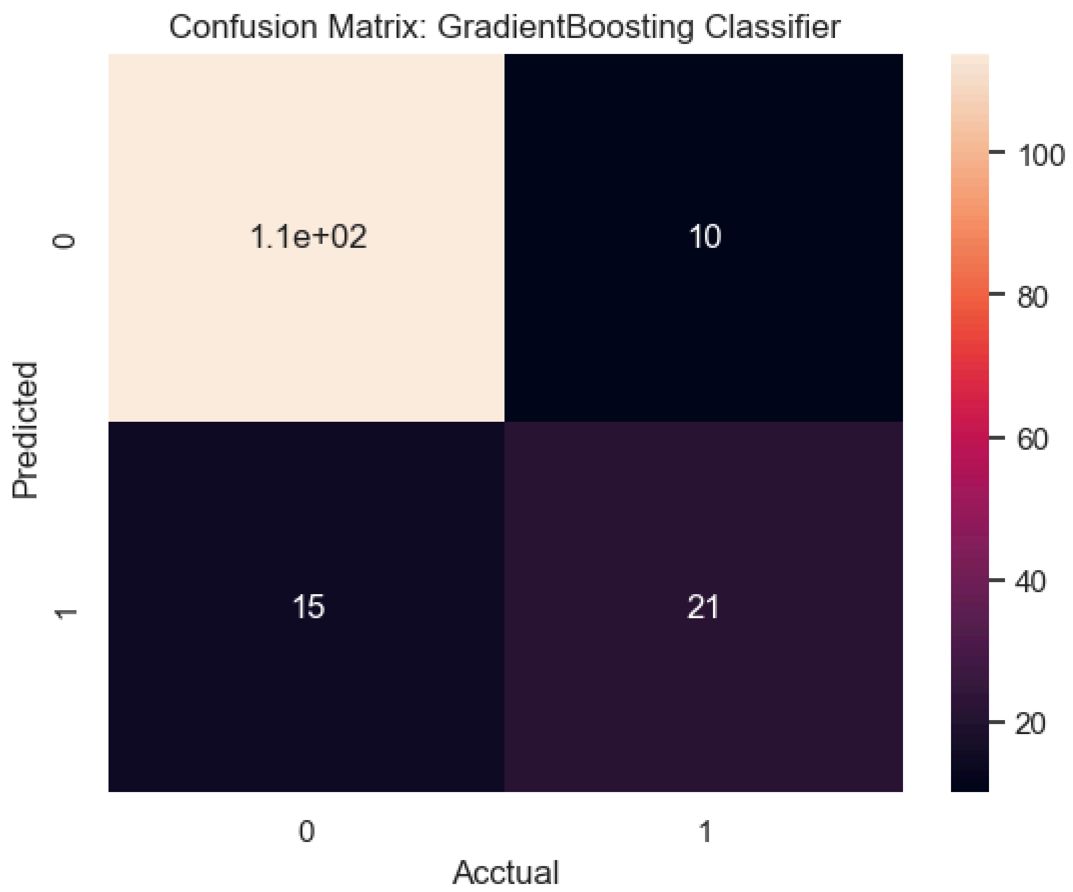
In [42]:
```
GB = GradientBoostingClassifier(learning_rate= 0.1, max_depth=1, n_estimators= 200, random_state=0)
GB.fit(X_train, y_train)
GB_predict = GB.predict(X_test)
print(f"GradientBoosting Classifier accuracy: {accuracy_score(y_test,GB_predict)}")
```

```
GradientBoosting Classifier accuracy: 0.84375
```

In [43]:
```
print(classification_report(y_test, GB_predict))
```

```
              precision    recall  f1-score   support

         0.0       0.88      0.92      0.90       124
         1.0       0.68      0.58      0.63        36

    accuracy                           0.84       160
   macro avg       0.78      0.75      0.76       160
weighted avg       0.84      0.84      0.84       160
```

In [44]:
```
GB_cfm = confusion_matrix(y_test, GB_predict)
sns.heatmap(GB_cfm, annot=True)
plt.xlabel('Acctual')
plt.ylabel('Predicted')
plt.title("Confusion Matrix: GradientBoosting Classifier")
plt.show()
```



AdaBoost Classifier

In [45]:
```
ad_base_model =  AdaBoostClassifier(random_state=0)
ad_param_grid = {
        'n_estimators':[ 10, 50, 80 ,100, 150, 200, 250, 300],
        'learning_rate': [0.01,0.02,0.1,0.05,0.5,0.07,0.9]
    }
ad_gs = GridSearchCV(estimator = ad_base_model, param_grid = ad_param_grid,cv=5, n_jobs = -1)
ad_gs.fit(X_train, y_train)
```

```
print(f'Best parameters for "AdaBoost Classifier": {ad_gs.best_params_}')
print(f'Best Accuracy: {ad_gs.best_score_}')
```

```
Best parameters for "AdaBoost Classifier": {'learning_rate': 0.1, 'n_estimators': 250}
Best Accuracy: 0.865625
```

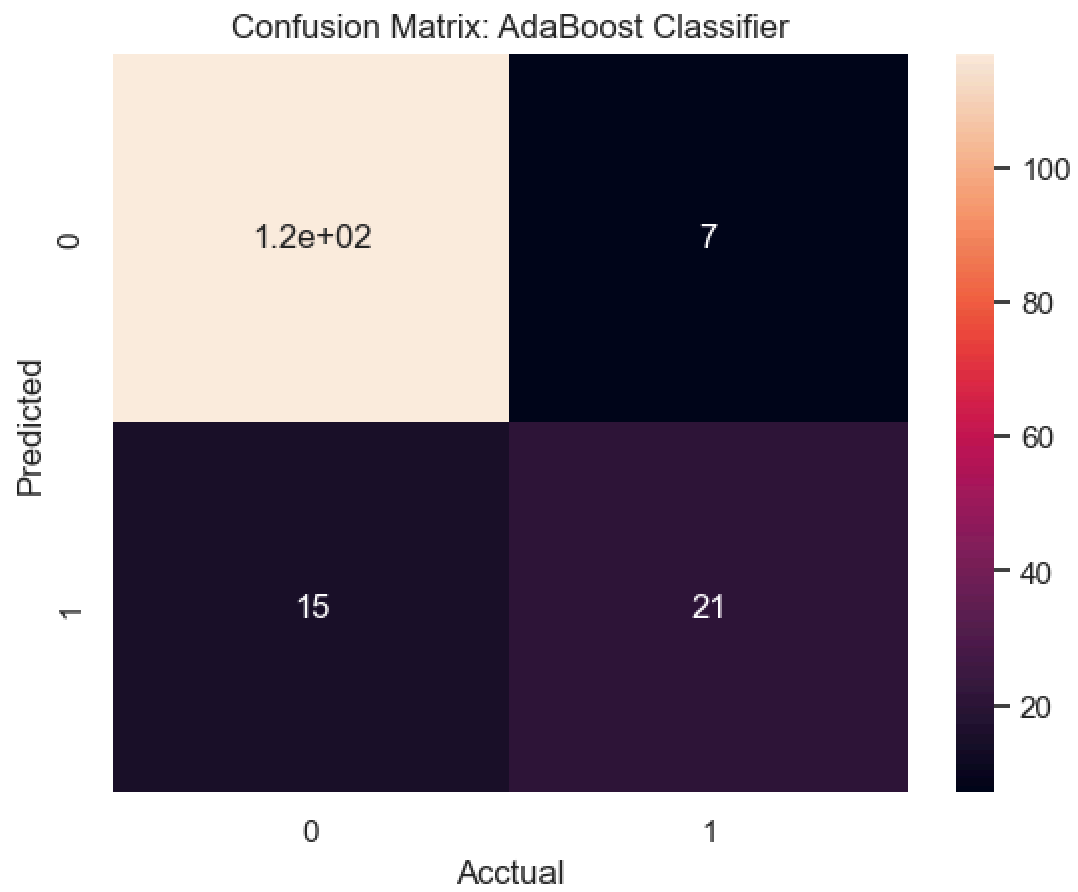
In [46]:
```
AB = AdaBoostClassifier(learning_rate= 0.1, n_estimators= 250, random_state=0)
AB.fit(X_train, y_train)
AB_predict = AB.predict(X_test)
print(f"AdaBoost Classifier accuracy: {accuracy_score(y_test,AB_predict)}")
```

```
AdaBoost Classifier accuracy: 0.8625
```

In [47]:
```
print(classification_report(y_test, AB_predict))
```

```
              precision    recall  f1-score   support

         0.0       0.89      0.94      0.91       124
         1.0       0.75      0.58      0.66        36

    accuracy                           0.86       160
   macro avg       0.82      0.76      0.79       160
weighted avg       0.86      0.86      0.86       160
```

In [48]:
```
AB_cfm = confusion_matrix(y_test, AB_predict)
sns.heatmap(AB_cfm, annot=True)
plt.xlabel('Acctual')
plt.ylabel('Predicted')
plt.title("Confusion Matrix: AdaBoost Classifier")
plt.show()
```



Result Summery

In [49]:
```
results = {
    'Logistic Regression': LR_predict,
    'Decision Tree': DT_predict,
    'RandomForest': RF_predict,
    'Bagging': BC_predict,
    'GradientBoosting': GB_predict,
    'AdaBoostClassifier': AB_predict
}
```

```python
for classifier, result in results.items():
    print(f"\nAccuracy of {classifier} classifier: {accuracy_score(y_test, result)}\n")
    print('-'*50)
```

```
Accuracy of Logistic Regression classifier: 0.875

--------------------------------------------------

Accuracy of Decision Tree classifier: 0.76875

--------------------------------------------------

Accuracy of RandomForest classifier: 0.8625

--------------------------------------------------

Accuracy of Bagging classifier: 0.825

--------------------------------------------------

Accuracy of GradientBoosting classifier: 0.84375

--------------------------------------------------

Accuracy of AdaBoostClassifier classifier: 0.8625

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

Conclusion: Logistic Regression is giving better result with accuracy score of 0.875

In [ ]: