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University ID: 2038584

You must use a dataset similar to that from Lab 1 for this part, but this time use the first 5 digits of your student number as the seed for random numbers.This is a classification task in which your neural network hopes to perform better than the decision tree method employed previously.

1. Train a scikit-learn MLP_Classifier to classify the dataset.

6CS012 Workshop 4

Question 1:

Train a scikit-learn MLPCLassifier to classify the dataset.

In [ ]:
```
# Importing the required libraries

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.datasets import make_classification
from sklearn.model_selection import train_test_split
from sklearn.neural_network import MLPClassifier
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report
```

In [31]:
```
# Generating a random n-class classification problem using make_classification()
# Student Number: 2038584
features, target = make_classification(
    n_samples=200, n_features=4, n_classes=3, n_clusters_per_class=1, random_state=2
```

In [32]:
```
# Getting total samples and feature
features.shape
```

Out[32]:
```
(200, 4)
```

In [33]:
```
# total targets for each samples
target.shape
```

Out[33]:
```
(200,)
```

In [34]:
```
# Getting first feature from the array
features[0]
```

Out[34]:
```
array([-2.31136138,  2.57148757, -0.0984496 ,  1.51270913])
```

In [35]:
```
# Getting the target of first feature
target[0]
```

Out[35]:
```
0
```

In [36]:
```
# Setting feature names and displaying them
feature_names = ['feature_0', 'feature_1', 'feature_2', 'feature_3']
feature_names
```

Out[36]:
```
['feature_0', 'feature_1', 'feature_2', 'feature_3']
```

In [37]:
```
# adding features to the dataframe
features_df = pd.DataFrame(features, columns=feature_names)
```

In [38]:
```
# viewing the first 5 rows of the features dataframe
features_df.head()
```

Out[38]:

	feature_0	feature_1	feature_2	feature_3
0	-2.311361	2.571488	-0.098450	1.512709
1	0.014013	-1.055202	-0.177304	-0.596043
2	-0.759459	-0.196307	-0.210527	-0.090749
3	-1.215190	1.155957	-0.085298	0.684661
4	-0.633451	1.635670	0.132321	0.940092

In [39]:
```
# Similarly, adding targets to the dataframe
target_df = pd.DataFrame(target, columns=['target'])
```

In [40]:
```
# viewing the first 5 rows of the target dataframe
target_df.head()
```

Out[40]:

	target
0	0
1	0
2	1
3	0
4	0

In [41]:
```
# Combining the two features and target dataframes to
# align each features to its respective targets
dataset = pd.concat([features_df, target_df], axis=1)
```

In [42]:
```
# viewing the features with their respective targets in a
# single dataframe, dataset.
dataset.head()
```

Out[42]:

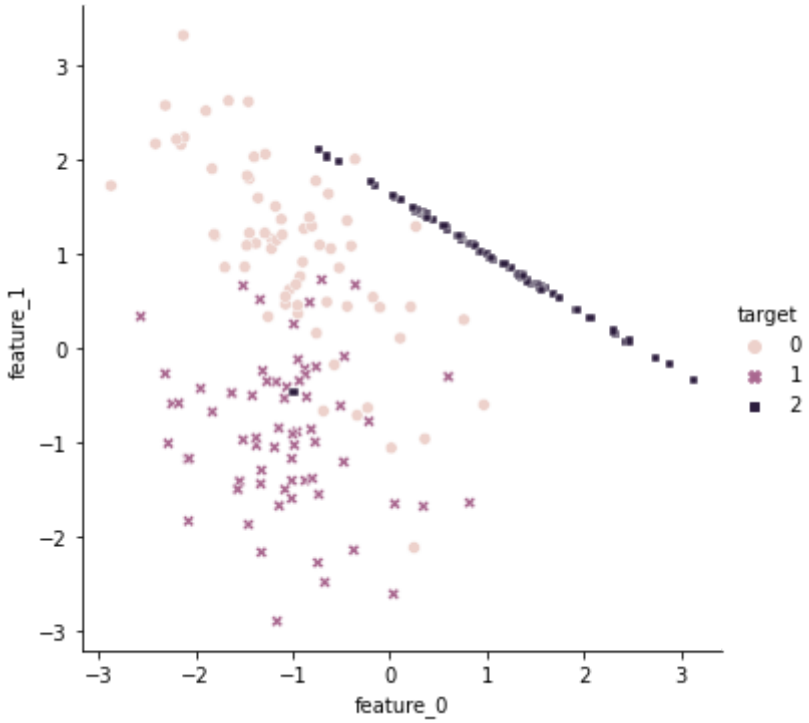
	feature_0	feature_1	feature_2	feature_3	target
0	-2.311361	2.571488	-0.098450	1.512709	0
1	0.014013	-1.055202	-0.177304	-0.596043	0
2	-0.759459	-0.196307	-0.210527	-0.090749	1

	feature_0	feature_1	feature_2	feature_3	target
3	-1.215190	1.155957	-0.085298	0.684661	0
4	-0.633451	1.635670	0.132321	0.940092	0

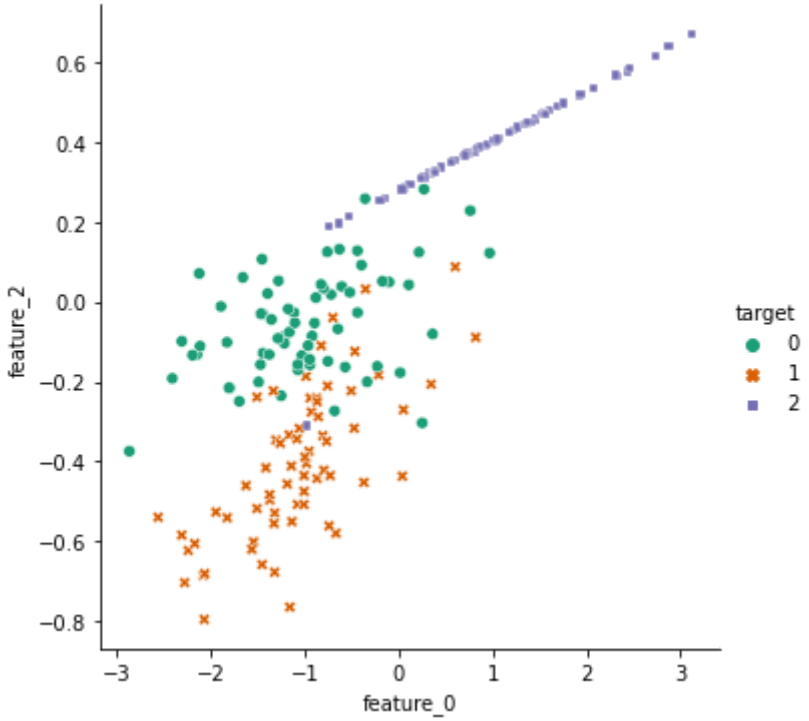
Relationship Plots

Here, the features were plotted and visulized their relationship between each other. Statistical analysis is the process of understanding how different variables are related to each other in a dataset and how they depend on other variables. By visualizing the data properly, we can see different patterns and trends which indicates the relationships.

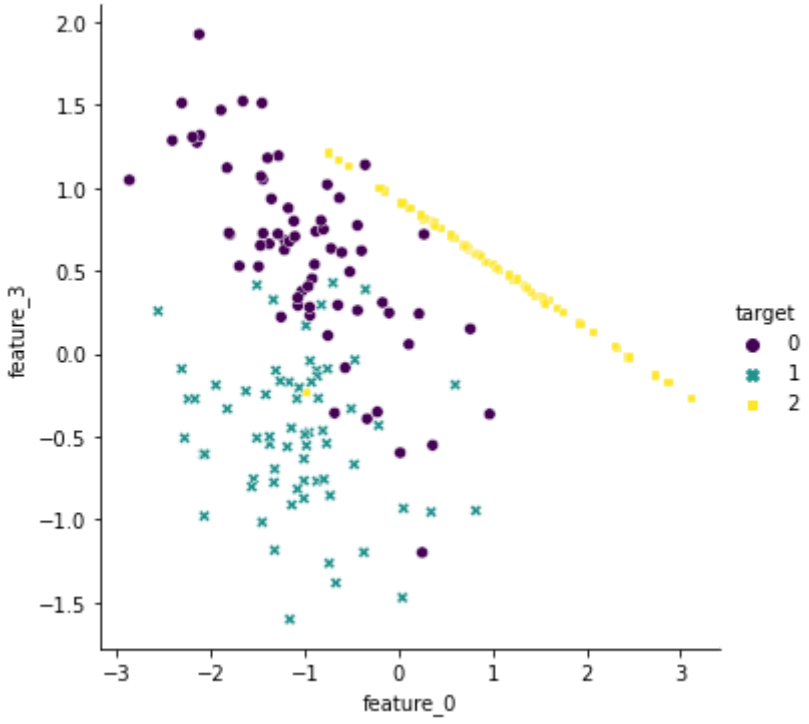
In [14]:
```
# Relationship between feature_0 and feature_1
sns.relplot(
    x='feature_0', y='feature_1', hue='target', style='target', data=dataset)
plt.show()
```



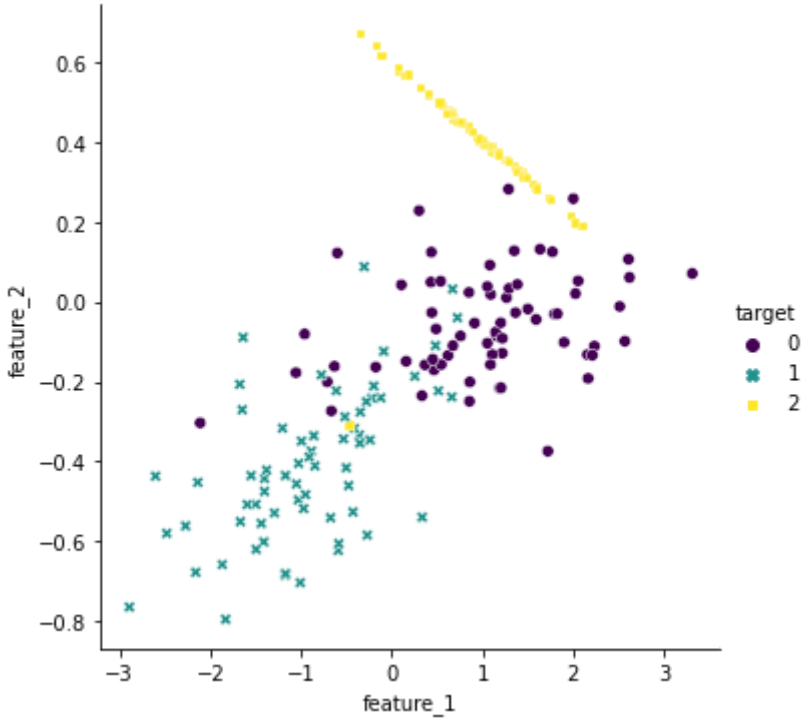
In [15]:
```
# Relationship between feature_0 and feature_2
sns.relplot(
    x='feature_0', y='feature_2', hue='target', style='target', palette='Dark2', dat
plt.show()
```



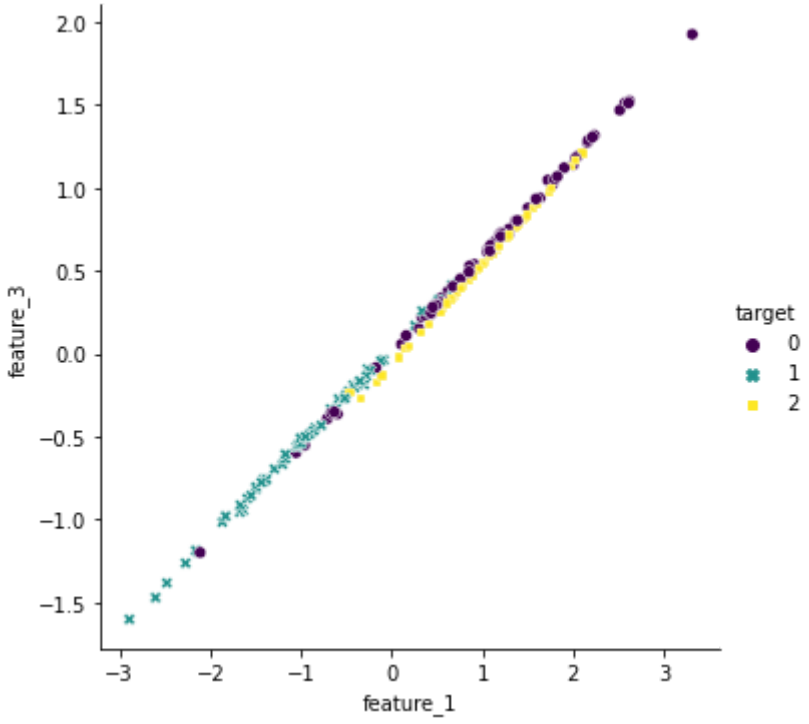
In [16]:
```
# Relationship between feature_0 and feature_3
sns.relplot(
    x='feature_0', y='feature_3', hue='target', style='target', palette='viridis', d
plt.show()
```



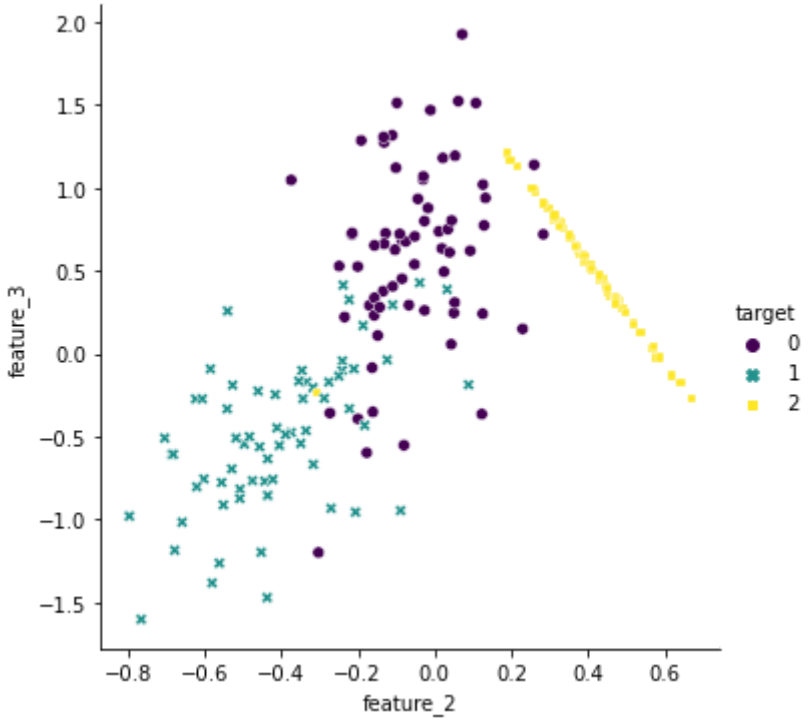
In [17]:
```
# Relationship between feature_1 and feature_2
sns.relplot(
    x='feature_1', y='feature_2', hue='target', style='target', palette='viridis', d
plt.show()
```



In [18]:
```
# Relationship between feature_1 and feature_3
sns.relplot(
    x='feature_1', y='feature_3', hue='target', style='target', palette='viridis', d
plt.show()
```



In [19]:
```
# Relationship between feature_2 and feature_3
sns.relplot(
    x='feature_2', y='feature_3', hue='target', style='target', palette='viridis', d
plt.show()
```



In [48]:
```
# Splitting the dataset into training and testing set
training_features, test_features, training_target, test_target = train_test_split(
    features, target, random_state=0)
```

In [49]:
```
# Showing the splition
print(training_features.shape, test_features.shape)
```

```
(160, 5) (40, 5)
```

In [58]:
```
# Using the MLPClassifier to train the model
# The DecisionTreeClassifier function was used earlier in Week 1
# to classify and this is also capable of performing
# multi-class classification on a given datasets.
# Our dataset contains 3 target labels,
# so it is also a multi class classification problem.
classifier = MLPClassifier(hidden_layer_sizes=(350,), max_iter=1000,activation = 're
                           solver='adam',random_state=1, batch_size=32, learning_rat
                            learning_rate_init=0.001, verbose=True)
```

In [59]:
```
classifier
```

Out[59]:
```
MLPClassifier(batch_size=32, hidden_layer_sizes=(350,), max_iter=1000,
              random_state=1, verbose=True)
```

In [60]:
```
# Fitting the data into the MLP_Classifier model
# Now, we fit the decision tree classifier model.
# Fitting is same as training and after the model,
# is trained the model can used to make predictions.
model=classifier.fit(training_features, training_target)
```

```
Iteration 1, loss = 1.06624187
Iteration 2, loss = 0.91203036
Iteration 3, loss = 0.78426111
Iteration 4, loss = 0.68730412
Iteration 5, loss = 0.60555848
Iteration 6, loss = 0.54288802
Iteration 7, loss = 0.49274009
Iteration 8, loss = 0.45332604
Iteration 9, loss = 0.42195977
Iteration 10, loss = 0.39720793
Iteration 11, loss = 0.37921449
```

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Iteration 12, loss = 0.36327465
Iteration 13, loss = 0.34970363
Iteration 14, loss = 0.33955647
Iteration 15, loss = 0.33013867
Iteration 16, loss = 0.32094717
Iteration 17, loss = 0.31377732
Iteration 18, loss = 0.30694934
Iteration 19, loss = 0.30086469
Iteration 20, loss = 0.29454956
Iteration 21, loss = 0.29031150
Iteration 22, loss = 0.28494826
Iteration 23, loss = 0.28051715
Iteration 24, loss = 0.27641630
Iteration 25, loss = 0.27251036
Iteration 26, loss = 0.26923923
Iteration 27, loss = 0.26509031
Iteration 28, loss = 0.26241443
Iteration 29, loss = 0.25906282
Iteration 30, loss = 0.25629291
Iteration 31, loss = 0.25361976
Iteration 32, loss = 0.25176419
Iteration 33, loss = 0.24939939
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Iteration 44, loss = 0.23102381
Iteration 45, loss = 0.23029839
Iteration 46, loss = 0.22901359
Iteration 47, loss = 0.22762126
Iteration 48, loss = 0.22697303
Iteration 49, loss = 0.22554925
Iteration 50, loss = 0.22439150
Iteration 51, loss = 0.22410033
Iteration 52, loss = 0.22282179
Iteration 53, loss = 0.22172809
Iteration 54, loss = 0.22083576
Iteration 55, loss = 0.21999334
Iteration 56, loss = 0.21902931
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Iteration 59, loss = 0.21622345
Iteration 60, loss = 0.21576042
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Iteration 63, loss = 0.21345747
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Iteration 65, loss = 0.21251977
Iteration 66, loss = 0.21129400
Iteration 67, loss = 0.21030315
Iteration 68, loss = 0.21031681
Iteration 69, loss = 0.20962304
Iteration 70, loss = 0.20840296
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Iteration 72, loss = 0.20757861
Iteration 73, loss = 0.20688814
Iteration 74, loss = 0.20645818
Iteration 75, loss = 0.20627432
Iteration 76, loss = 0.20555454
Iteration 77, loss = 0.20430828
Iteration 78, loss = 0.20343771
Iteration 79, loss = 0.20304656
Iteration 80, loss = 0.20356617
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Iteration 82, loss = 0.20173351
Iteration 83, loss = 0.20216870
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Iteration 123, loss = 0.18452542
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Iteration 127, loss = 0.18363304
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Iteration 334, loss = 0.14259316
Iteration 335, loss = 0.14263196
Iteration 336, loss = 0.14198509
Iteration 337, loss = 0.14241984
Iteration 338, loss = 0.14171212
Iteration 339, loss = 0.14147519
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Iteration 341, loss = 0.14155725
Iteration 342, loss = 0.14196620
Iteration 343, loss = 0.14209038
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Iteration 345, loss = 0.14111220
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Iteration 363, loss = 0.13861951
Iteration 364, loss = 0.13931342
Iteration 365, loss = 0.13851850
Iteration 366, loss = 0.13854113
Iteration 367, loss = 0.13818887
Iteration 368, loss = 0.13740459
Iteration 369, loss = 0.13749246
Iteration 370, loss = 0.13855374
Iteration 371, loss = 0.13877616
Iteration 372, loss = 0.13749135
Iteration 373, loss = 0.13748501
Iteration 374, loss = 0.13811793
Iteration 375, loss = 0.13692011
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Iteration 378, loss = 0.13730858
Iteration 379, loss = 0.13774628
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Iteration 389, loss = 0.13667034
Iteration 390, loss = 0.13573112
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Iteration 630, loss = 0.11177859
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Iteration 633, loss = 0.11108229
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Iteration 654, loss = 0.10916908
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Iteration 664, loss = 0.10977988
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Iteration 666, loss = 0.10775967
Iteration 667, loss = 0.10983601
Iteration 668, loss = 0.10892775
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Iteration 670, loss = 0.10817615
Iteration 671, loss = 0.10835719
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Iteration 674, loss = 0.10804477
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Iteration 680, loss = 0.10798206
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Iteration 693, loss = 0.10709156
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Iteration 695, loss = 0.10651390
Iteration 696, loss = 0.10730647
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Iteration 698, loss = 0.10692853
Iteration 699, loss = 0.10636023
Iteration 700, loss = 0.10547185
Iteration 701, loss = 0.10558066
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Iteration 702, loss = 0.10626018
Iteration 703, loss = 0.10754598
Iteration 704, loss = 0.10668490
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Iteration 706, loss = 0.10548936
Iteration 707, loss = 0.10520869
Iteration 708, loss = 0.10509372
Iteration 709, loss = 0.10509236
Iteration 710, loss = 0.10501472
Iteration 711, loss = 0.10664373
Iteration 712, loss = 0.10535025
Iteration 713, loss = 0.10598889
Iteration 714, loss = 0.10607077
Iteration 715, loss = 0.10509206
Iteration 716, loss = 0.10591156
Iteration 717, loss = 0.10550962
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Iteration 719, loss = 0.10466533
Iteration 720, loss = 0.10474801
Iteration 721, loss = 0.10514299
Iteration 722, loss = 0.10548646
Iteration 723, loss = 0.10535756
Iteration 724, loss = 0.10547041
Iteration 725, loss = 0.10402472
Iteration 726, loss = 0.10453805
Iteration 727, loss = 0.10375015
Iteration 728, loss = 0.10466744
Iteration 729, loss = 0.10439075
Iteration 730, loss = 0.10456278
Iteration 731, loss = 0.10453411
Iteration 732, loss = 0.10471329
Iteration 733, loss = 0.10298797
Iteration 734, loss = 0.10403667
Iteration 735, loss = 0.10471251
Iteration 736, loss = 0.10325215
Iteration 737, loss = 0.10337551
Iteration 738, loss = 0.10345626
Iteration 739, loss = 0.10365843
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Iteration 741, loss = 0.10376623
Iteration 742, loss = 0.10317199
Iteration 743, loss = 0.10525198
Iteration 744, loss = 0.10249582
Iteration 745, loss = 0.10312853
Iteration 746, loss = 0.10380549
Iteration 747, loss = 0.10245269
Iteration 748, loss = 0.10216478
Iteration 749, loss = 0.10269138
Iteration 750, loss = 0.10322024
Iteration 751, loss = 0.10408005
Iteration 752, loss = 0.10297190
Iteration 753, loss = 0.10239721
Iteration 754, loss = 0.10353346
Iteration 755, loss = 0.10215560
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Iteration 759, loss = 0.10228542
Iteration 760, loss = 0.10170754
Iteration 761, loss = 0.10197666
Iteration 762, loss = 0.10172410
Iteration 763, loss = 0.10111082
Iteration 764, loss = 0.10269887
Iteration 765, loss = 0.10143576
Iteration 766, loss = 0.10203190
Iteration 767, loss = 0.10150693
Iteration 768, loss = 0.10147394
Iteration 769, loss = 0.10158827
Iteration 770, loss = 0.10281608
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Iteration 771, loss = 0.10201651
Iteration 772, loss = 0.10126676
Iteration 773, loss = 0.10208132
Iteration 774, loss = 0.10245563
Training loss did not improve more than tol=0.000100 for 10 consecutive epochs. Stop
ping.
```

In [61]:
```
# Predicting for the test features to test the performance,
# of our MLP_Classifier model.
predictions = model.predict(test_features)
```

In [62]:
```
# Creating confusion matrix from predictions
matrix = confusion_matrix(predictions, test_target)
```

In [63]:
```
# Displaying the confusion matrix
print(matrix)
```

```
[[ 9  5  3]
 [ 2 14  0]
 [ 0  0 17]]
```

In [64]:
```
# showing the classification report for the predictions
print(classification_report(test_target, predictions))
```

```
              precision    recall  f1-score   support

           0       0.53      0.82      0.64        11
           1       0.88      0.74      0.80        19
           2       1.00      0.85      0.92        20

    accuracy                           0.80        50
   macro avg       0.80      0.80      0.79        50
weighted avg       0.85      0.80      0.81        50
```

Question 2:

Write a paragraph to explain how the confusion matrix and other metrics regard the MPL or decision tree to be most applicable.

Confusion matrix is extremely useful to measure Recall, Precision, Specificity, Accuracy and most importantly AUC-ROC Curve.....

Question 3:

Experiment with 3 hyper-parameters included in the lecture and write a short summary of what you have learnt.

As we already know that MLP is best for this classification task, we can experiment changing some hyper-parameters to see if there will be some improvement in the performance of the model.

Experiment 1:

Changing the following paramaters: Hidden Layer: 500 batch_size: auto activation function: relu loss function: adam

In [66]:
```
classifier1 = MLPClassifier(hidden_layer_sizes=(500,), max_iter=1000,activation = 'r
                            solver='adam',random_state=1, batch_size="auto", learning
                             learning_rate_init=0.001, verbose=True)
```

In [67]:
```
classifier1
```

Out[67]:
```
MLPClassifier(hidden_layer_sizes=(500,), max_iter=1000, random_state=1,
              verbose=True)
```

In [74]:
```
model1=classifier1.fit(training_features, training_target)
```

```
Iteration 1, loss = 1.09928572
Iteration 2, loss = 1.05516942
Iteration 3, loss = 1.01279029
Iteration 4, loss = 0.97216335
Iteration 5, loss = 0.93331691
Iteration 6, loss = 0.89626469
Iteration 7, loss = 0.86102389
Iteration 8, loss = 0.82754449
Iteration 9, loss = 0.79576744
Iteration 10, loss = 0.76566994
Iteration 11, loss = 0.73719945
Iteration 12, loss = 0.71028295
Iteration 13, loss = 0.68486301
Iteration 14, loss = 0.66090042
Iteration 15, loss = 0.63830825
Iteration 16, loss = 0.61703447
Iteration 17, loss = 0.59701847
Iteration 18, loss = 0.57818177
Iteration 19, loss = 0.56047222
Iteration 20, loss = 0.54382365
Iteration 21, loss = 0.52819549
Iteration 22, loss = 0.51353260
Iteration 23, loss = 0.49978811
Iteration 24, loss = 0.48691474
Iteration 25, loss = 0.47486468
Iteration 26, loss = 0.46357531
Iteration 27, loss = 0.45299977
Iteration 28, loss = 0.44310712
Iteration 29, loss = 0.43386024
Iteration 30, loss = 0.42522006
Iteration 31, loss = 0.41714213
Iteration 32, loss = 0.40957236
Iteration 33, loss = 0.40248247
Iteration 34, loss = 0.39582869
Iteration 35, loss = 0.38958801
Iteration 36, loss = 0.38374845
Iteration 37, loss = 0.37827943
Iteration 38, loss = 0.37312708
Iteration 39, loss = 0.36826614
Iteration 40, loss = 0.36366955
Iteration 41, loss = 0.35932310
Iteration 42, loss = 0.35520401
Iteration 43, loss = 0.35128691
Iteration 44, loss = 0.34755613
Iteration 45, loss = 0.34399227
Iteration 46, loss = 0.34058032
Iteration 47, loss = 0.33730848
Iteration 48, loss = 0.33416793
Iteration 49, loss = 0.33115400
Iteration 50, loss = 0.32824818
Iteration 51, loss = 0.32543681
Iteration 52, loss = 0.32271363
Iteration 53, loss = 0.32007746
Iteration 54, loss = 0.31752261
Iteration 55, loss = 0.31504660
Iteration 56, loss = 0.31264342
Iteration 57, loss = 0.31031294
Iteration 58, loss = 0.30805645
Iteration 59, loss = 0.30586770
Iteration 60, loss = 0.30374356
Iteration 61, loss = 0.30167379
Iteration 62, loss = 0.29965957
Iteration 63, loss = 0.29769556
Iteration 64, loss = 0.29578461
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Iteration 65, loss = 0.29392231
Iteration 66, loss = 0.29210725
Iteration 67, loss = 0.29034150
Iteration 68, loss = 0.28861783
Iteration 69, loss = 0.28693426
Iteration 70, loss = 0.28529056
Iteration 71, loss = 0.28368298
Iteration 72, loss = 0.28210807
Iteration 73, loss = 0.28056916
Iteration 74, loss = 0.27906233
Iteration 75, loss = 0.27758546
Iteration 76, loss = 0.27614065
Iteration 77, loss = 0.27472441
Iteration 78, loss = 0.27333524
Iteration 79, loss = 0.27197358
Iteration 80, loss = 0.27063711
Iteration 81, loss = 0.26932458
Iteration 82, loss = 0.26803645
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Iteration 85, loss = 0.26430871
Iteration 86, loss = 0.26310657
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Iteration 100, loss = 0.24823249
Iteration 101, loss = 0.24729035
Iteration 102, loss = 0.24636444
Iteration 103, loss = 0.24545417
Iteration 104, loss = 0.24456043
Iteration 105, loss = 0.24368200
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Iteration 111, loss = 0.23874519
Iteration 112, loss = 0.23797649
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Iteration 114, loss = 0.23647909
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Iteration 118, loss = 0.23363449
Iteration 119, loss = 0.23295424
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Iteration 128, loss = 0.22734720
Iteration 129, loss = 0.22677201
Iteration 130, loss = 0.22620640
Iteration 131, loss = 0.22564972
Iteration 132, loss = 0.22510298
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Iteration 134, loss = 0.22404759
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Iteration 158, loss = 0.21363578
Iteration 159, loss = 0.21326822
Iteration 160, loss = 0.21290480
Iteration 161, loss = 0.21254607
Iteration 162, loss = 0.21219135
Iteration 163, loss = 0.21184096
Iteration 164, loss = 0.21149526
Iteration 165, loss = 0.21115368
Iteration 166, loss = 0.21081581
Iteration 167, loss = 0.21047996
Iteration 168, loss = 0.21014643
Iteration 169, loss = 0.20981415
Iteration 170, loss = 0.20948378
Iteration 171, loss = 0.20915530
Iteration 172, loss = 0.20883143
Iteration 173, loss = 0.20851145
Iteration 174, loss = 0.20819663
Iteration 175, loss = 0.20788507
Iteration 176, loss = 0.20757650
Iteration 177, loss = 0.20727158
Iteration 178, loss = 0.20696933
Iteration 179, loss = 0.20666848
Iteration 180, loss = 0.20636995
Iteration 181, loss = 0.20607340
Iteration 182, loss = 0.20577912
Iteration 183, loss = 0.20548665
Iteration 184, loss = 0.20519768
Iteration 185, loss = 0.20490990
Iteration 186, loss = 0.20462334
Iteration 187, loss = 0.20433798
Iteration 188, loss = 0.20405552
Iteration 189, loss = 0.20377450
Iteration 190, loss = 0.20349536
Iteration 191, loss = 0.20321795
Iteration 192, loss = 0.20294240
Iteration 193, loss = 0.20266871
Iteration 194, loss = 0.20239706
Iteration 195, loss = 0.20212662
Iteration 196, loss = 0.20185805
Iteration 197, loss = 0.20159164
Iteration 198, loss = 0.20132694
Iteration 199, loss = 0.20106369
Iteration 200, loss = 0.20080128
Iteration 201, loss = 0.20053985
Iteration 202, loss = 0.20027984
```

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Iteration 203, loss = 0.20002094
Iteration 204, loss = 0.19976244
Iteration 205, loss = 0.19950174
Iteration 206, loss = 0.19924033
Iteration 207, loss = 0.19897811
Iteration 208, loss = 0.19872213
Iteration 209, loss = 0.19846599
Iteration 210, loss = 0.19820836
Iteration 211, loss = 0.19794809
Iteration 212, loss = 0.19768893
Iteration 213, loss = 0.19742901
Iteration 214, loss = 0.19716395
Iteration 215, loss = 0.19690958
Iteration 216, loss = 0.19665646
Iteration 217, loss = 0.19640414
Iteration 218, loss = 0.19615432
Iteration 219, loss = 0.19590649
Iteration 220, loss = 0.19565914
Iteration 221, loss = 0.19541206
Iteration 222, loss = 0.19516598
Iteration 223, loss = 0.19492135
Iteration 224, loss = 0.19467871
Iteration 225, loss = 0.19443795
Iteration 226, loss = 0.19419856
Iteration 227, loss = 0.19395816
Iteration 228, loss = 0.19371596
Iteration 229, loss = 0.19347432
Iteration 230, loss = 0.19323540
Iteration 231, loss = 0.19299886
Iteration 232, loss = 0.19276486
Iteration 233, loss = 0.19253214
Iteration 234, loss = 0.19230050
Iteration 235, loss = 0.19207164
Iteration 236, loss = 0.19184465
Iteration 237, loss = 0.19161953
Iteration 238, loss = 0.19139520
Iteration 239, loss = 0.19117096
Iteration 240, loss = 0.19094691
Iteration 241, loss = 0.19072315
Iteration 242, loss = 0.19050193
Iteration 243, loss = 0.19028153
Iteration 244, loss = 0.19006276
Iteration 245, loss = 0.18984507
Iteration 246, loss = 0.18962740
Iteration 247, loss = 0.18941079
Iteration 248, loss = 0.18919411
Iteration 249, loss = 0.18897734
Iteration 250, loss = 0.18876322
Iteration 251, loss = 0.18855087
Iteration 252, loss = 0.18833736
Iteration 253, loss = 0.18812436
Iteration 254, loss = 0.18791170
Iteration 255, loss = 0.18769888
Iteration 256, loss = 0.18748589
Iteration 257, loss = 0.18727315
Iteration 258, loss = 0.18706286
Iteration 259, loss = 0.18685478
Iteration 260, loss = 0.18664968
Iteration 261, loss = 0.18644463
Iteration 262, loss = 0.18624046
Iteration 263, loss = 0.18603634
Iteration 264, loss = 0.18583354
Iteration 265, loss = 0.18563059
Iteration 266, loss = 0.18542794
Iteration 267, loss = 0.18522777
Iteration 268, loss = 0.18502739
Iteration 269, loss = 0.18482708
Iteration 270, loss = 0.18462443
Iteration 271, loss = 0.18442062
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Iteration 272, loss = 0.18421624
Iteration 273, loss = 0.18401198
Iteration 274, loss = 0.18380650
Iteration 275, loss = 0.18360497
Iteration 276, loss = 0.18340891
Iteration 277, loss = 0.18321328
Iteration 278, loss = 0.18301858
Iteration 279, loss = 0.18282316
Iteration 280, loss = 0.18262671
Iteration 281, loss = 0.18243163
Iteration 282, loss = 0.18223675
Iteration 283, loss = 0.18204247
Iteration 284, loss = 0.18184954
Iteration 285, loss = 0.18165806
Iteration 286, loss = 0.18146730
Iteration 287, loss = 0.18127199
Iteration 288, loss = 0.18107529
Iteration 289, loss = 0.18088571
Iteration 290, loss = 0.18069655
Iteration 291, loss = 0.18050818
Iteration 292, loss = 0.18031941
Iteration 293, loss = 0.18013111
Iteration 294, loss = 0.17994443
Iteration 295, loss = 0.17975862
Iteration 296, loss = 0.17957228
Iteration 297, loss = 0.17938747
Iteration 298, loss = 0.17920362
Iteration 299, loss = 0.17901862
Iteration 300, loss = 0.17883575
Iteration 301, loss = 0.17865716
Iteration 302, loss = 0.17847985
Iteration 303, loss = 0.17830168
Iteration 304, loss = 0.17812261
Iteration 305, loss = 0.17794280
Iteration 306, loss = 0.17776270
Iteration 307, loss = 0.17758450
Iteration 308, loss = 0.17740623
Iteration 309, loss = 0.17722892
Iteration 310, loss = 0.17705167
Iteration 311, loss = 0.17687700
Iteration 312, loss = 0.17670253
Iteration 313, loss = 0.17652912
Iteration 314, loss = 0.17635597
Iteration 315, loss = 0.17618333
Iteration 316, loss = 0.17601023
Iteration 317, loss = 0.17583755
Iteration 318, loss = 0.17566525
Iteration 319, loss = 0.17549499
Iteration 320, loss = 0.17532645
Iteration 321, loss = 0.17515738
Iteration 322, loss = 0.17498895
Iteration 323, loss = 0.17482186
Iteration 324, loss = 0.17465500
Iteration 325, loss = 0.17448832
Iteration 326, loss = 0.17432266
Iteration 327, loss = 0.17415873
Iteration 328, loss = 0.17399722
Iteration 329, loss = 0.17383405
Iteration 330, loss = 0.17367215
Iteration 331, loss = 0.17351112
Iteration 332, loss = 0.17334981
Iteration 333, loss = 0.17318622
Iteration 334, loss = 0.17302154
Iteration 335, loss = 0.17285511
Iteration 336, loss = 0.17268872
Iteration 337, loss = 0.17252309
Iteration 338, loss = 0.17235698
Iteration 339, loss = 0.17218967
Iteration 340, loss = 0.17202375
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Iteration 341, loss = 0.17186394
Iteration 342, loss = 0.17170299
Iteration 343, loss = 0.17154521
Iteration 344, loss = 0.17138552
Iteration 345, loss = 0.17122662
Iteration 346, loss = 0.17106806
Iteration 347, loss = 0.17090883
Iteration 348, loss = 0.17075150
Iteration 349, loss = 0.17059549
Iteration 350, loss = 0.17043938
Iteration 351, loss = 0.17028392
Iteration 352, loss = 0.17013116
Iteration 353, loss = 0.16997915
Iteration 354, loss = 0.16982677
Iteration 355, loss = 0.16967676
Iteration 356, loss = 0.16952741
Iteration 357, loss = 0.16937723
Iteration 358, loss = 0.16922975
Iteration 359, loss = 0.16908254
Iteration 360, loss = 0.16893474
Iteration 361, loss = 0.16878712
Iteration 362, loss = 0.16863790
Iteration 363, loss = 0.16849357
Iteration 364, loss = 0.16834806
Iteration 365, loss = 0.16820377
Iteration 366, loss = 0.16805909
Iteration 367, loss = 0.16791572
Iteration 368, loss = 0.16777288
Iteration 369, loss = 0.16763230
Iteration 370, loss = 0.16749257
Iteration 371, loss = 0.16735226
Iteration 372, loss = 0.16721187
Iteration 373, loss = 0.16707078
Iteration 374, loss = 0.16693140
Iteration 375, loss = 0.16679095
Iteration 376, loss = 0.16664928
Iteration 377, loss = 0.16651190
Iteration 378, loss = 0.16637580
Iteration 379, loss = 0.16623904
Iteration 380, loss = 0.16610071
Iteration 381, loss = 0.16596125
Iteration 382, loss = 0.16582463
Iteration 383, loss = 0.16568743
Iteration 384, loss = 0.16555047
Iteration 385, loss = 0.16541515
Iteration 386, loss = 0.16528048
Iteration 387, loss = 0.16514483
Iteration 388, loss = 0.16501039
Iteration 389, loss = 0.16487806
Iteration 390, loss = 0.16474419
Iteration 391, loss = 0.16460950
Iteration 392, loss = 0.16447448
Iteration 393, loss = 0.16434110
Iteration 394, loss = 0.16420994
Iteration 395, loss = 0.16407803
Iteration 396, loss = 0.16394513
Iteration 397, loss = 0.16381228
Iteration 398, loss = 0.16368236
Iteration 399, loss = 0.16355395
Iteration 400, loss = 0.16342608
Iteration 401, loss = 0.16329789
Iteration 402, loss = 0.16317094
Iteration 403, loss = 0.16304426
Iteration 404, loss = 0.16291625
Iteration 405, loss = 0.16278850
Iteration 406, loss = 0.16266128
Iteration 407, loss = 0.16253274
Iteration 408, loss = 0.16240436
Iteration 409, loss = 0.16227784
```

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Iteration 410, loss = 0.16214993
Iteration 411, loss = 0.16202318
Iteration 412, loss = 0.16190259
Iteration 413, loss = 0.16178081
Iteration 414, loss = 0.16165719
Iteration 415, loss = 0.16153187
Iteration 416, loss = 0.16140804
Iteration 417, loss = 0.16128965
Iteration 418, loss = 0.16116940
Iteration 419, loss = 0.16104577
Iteration 420, loss = 0.16092286
Iteration 421, loss = 0.16080259
Iteration 422, loss = 0.16068014
Iteration 423, loss = 0.16055921
Iteration 424, loss = 0.16044050
Iteration 425, loss = 0.16032115
Iteration 426, loss = 0.16020136
Iteration 427, loss = 0.16008297
Iteration 428, loss = 0.15996419
Iteration 429, loss = 0.15984735
Iteration 430, loss = 0.15973152
Iteration 431, loss = 0.15961536
Iteration 432, loss = 0.15950177
Iteration 433, loss = 0.15938917
Iteration 434, loss = 0.15927690
Iteration 435, loss = 0.15916213
Iteration 436, loss = 0.15904986
Iteration 437, loss = 0.15893825
Iteration 438, loss = 0.15882902
Iteration 439, loss = 0.15871690
Iteration 440, loss = 0.15860605
Iteration 441, loss = 0.15849352
Iteration 442, loss = 0.15838059
Iteration 443, loss = 0.15827083
Iteration 444, loss = 0.15816435
Iteration 445, loss = 0.15805438
Iteration 446, loss = 0.15794349
Iteration 447, loss = 0.15783502
Iteration 448, loss = 0.15772476
Iteration 449, loss = 0.15761541
Iteration 450, loss = 0.15750634
Iteration 451, loss = 0.15739653
Iteration 452, loss = 0.15728568
Iteration 453, loss = 0.15717758
Iteration 454, loss = 0.15706928
Iteration 455, loss = 0.15696353
Iteration 456, loss = 0.15685969
Iteration 457, loss = 0.15675462
Iteration 458, loss = 0.15664613
Iteration 459, loss = 0.15654002
Iteration 460, loss = 0.15643791
Iteration 461, loss = 0.15633318
Iteration 462, loss = 0.15622753
Iteration 463, loss = 0.15611865
Iteration 464, loss = 0.15601128
Iteration 465, loss = 0.15590408
Iteration 466, loss = 0.15579842
Iteration 467, loss = 0.15569147
Iteration 468, loss = 0.15558405
Iteration 469, loss = 0.15547621
Iteration 470, loss = 0.15537097
Iteration 471, loss = 0.15526874
Iteration 472, loss = 0.15516258
Iteration 473, loss = 0.15505609
Iteration 474, loss = 0.15495231
Iteration 475, loss = 0.15484821
Iteration 476, loss = 0.15474469
Iteration 477, loss = 0.15464364
Iteration 478, loss = 0.15454304
```

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Iteration 479, loss = 0.15444143
Iteration 480, loss = 0.15433883
Iteration 481, loss = 0.15423420
Iteration 482, loss = 0.15413303
Iteration 483, loss = 0.15403014
Iteration 484, loss = 0.15392714
Iteration 485, loss = 0.15382711
Iteration 486, loss = 0.15372421
Iteration 487, loss = 0.15362176
Iteration 488, loss = 0.15352104
Iteration 489, loss = 0.15342152
Iteration 490, loss = 0.15332033
Iteration 491, loss = 0.15321746
Iteration 492, loss = 0.15311993
Iteration 493, loss = 0.15302135
Iteration 494, loss = 0.15292082
Iteration 495, loss = 0.15282269
Iteration 496, loss = 0.15272290
Iteration 497, loss = 0.15262362
Iteration 498, loss = 0.15252337
Iteration 499, loss = 0.15242246
Iteration 500, loss = 0.15232749
Iteration 501, loss = 0.15223018
Iteration 502, loss = 0.15212776
Iteration 503, loss = 0.15203192
Iteration 504, loss = 0.15193521
Iteration 505, loss = 0.15183386
Iteration 506, loss = 0.15173221
Iteration 507, loss = 0.15163440
Iteration 508, loss = 0.15153602
Iteration 509, loss = 0.15143846
Iteration 510, loss = 0.15133964
Iteration 511, loss = 0.15124174
Iteration 512, loss = 0.15114251
Iteration 513, loss = 0.15104360
Iteration 514, loss = 0.15094743
Iteration 515, loss = 0.15084917
Iteration 516, loss = 0.15074547
Iteration 517, loss = 0.15064702
Iteration 518, loss = 0.15055108
Iteration 519, loss = 0.15045055
Iteration 520, loss = 0.15035108
Iteration 521, loss = 0.15025383
Iteration 522, loss = 0.15015591
Iteration 523, loss = 0.15005714
Iteration 524, loss = 0.14995827
Iteration 525, loss = 0.14986144
Iteration 526, loss = 0.14976357
Iteration 527, loss = 0.14966299
Iteration 528, loss = 0.14956610
Iteration 529, loss = 0.14946776
Iteration 530, loss = 0.14937127
Iteration 531, loss = 0.14927129
Iteration 532, loss = 0.14917318
Iteration 533, loss = 0.14907282
Iteration 534, loss = 0.14897747
Iteration 535, loss = 0.14888290
Iteration 536, loss = 0.14878622
Iteration 537, loss = 0.14868661
Iteration 538, loss = 0.14858578
Iteration 539, loss = 0.14848826
Iteration 540, loss = 0.14838596
Iteration 541, loss = 0.14828874
Iteration 542, loss = 0.14818921
Iteration 543, loss = 0.14809373
Iteration 544, loss = 0.14799704
Iteration 545, loss = 0.14789902
Iteration 546, loss = 0.14780531
Iteration 547, loss = 0.14771511
```

```
Iteration 548, loss = 0.14762169
Iteration 549, loss = 0.14752616
Iteration 550, loss = 0.14742994
Iteration 551, loss = 0.14733257
Training loss did not improve more than tol=0.000100 for 10 consecutive epochs. Stop
ping.
```

In [83]:
```
predictions1 = model1.predict(test_features)
```

In [88]:
```
matrix1 = confusion_matrix(predictions1, test_target)
```

In [89]:
```
print(matrix1)
```

```
[[10  5  4]
 [ 1 14  0]
 [ 0  0 16]]
```

In [90]:
```
print(classification_report(test_target, predictions1))
```

```
              precision    recall  f1-score   support

           0       0.53      0.91      0.67        11
           1       0.93      0.74      0.82        19
           2       1.00      0.80      0.89        20

    accuracy                           0.80        50
   macro avg       0.82      0.82      0.79        50
weighted avg       0.87      0.80      0.82        50
```

Experiment 2:

Changing the following paramaters: Hidden Layer: 350 batch_size: auto learning rate: adaptive activation function: relu loss function: sgd

In [80]:
```
classifier2 = MLPClassifier(hidden_layer_sizes=(350,), max_iter=1000,activation = 'r
                            solver='sgd',random_state=1, batch_size="auto", learning_
                             learning_rate_init=0.001, verbose=True)
```

In [81]:
```
model2=classifier2.fit(training_features, training_target)
```

```
Iteration 1, loss = 1.13144270
Iteration 2, loss = 1.12943453
Iteration 3, loss = 1.12658076
Iteration 4, loss = 1.12297607
Iteration 5, loss = 1.11870836
Iteration 6, loss = 1.11385695
Iteration 7, loss = 1.10849553
Iteration 8, loss = 1.10269080
Iteration 9, loss = 1.09650262
Iteration 10, loss = 1.08998644
Iteration 11, loss = 1.08319034
Iteration 12, loss = 1.07616075
Iteration 13, loss = 1.06893976
Iteration 14, loss = 1.06156535
Iteration 15, loss = 1.05407134
Iteration 16, loss = 1.04648618
Iteration 17, loss = 1.03883566
Iteration 18, loss = 1.03114322
Iteration 19, loss = 1.02343018
Iteration 20, loss = 1.01571446
Iteration 21, loss = 1.00801164
Iteration 22, loss = 1.00033321
Iteration 23, loss = 0.99269622
Iteration 24, loss = 0.98511370
Iteration 25, loss = 0.97759038
Iteration 26, loss = 0.97013441
```

```
Iteration 27, loss = 0.96275331
Iteration 28, loss = 0.95545727
Iteration 29, loss = 0.94824680
Iteration 30, loss = 0.94112217
Iteration 31, loss = 0.93408842
Iteration 32, loss = 0.92714559
Iteration 33, loss = 0.92029463
Iteration 34, loss = 0.91353787
Iteration 35, loss = 0.90687982
Iteration 36, loss = 0.90031964
Iteration 37, loss = 0.89385702
Iteration 38, loss = 0.88749564
Iteration 39, loss = 0.88123360
Iteration 40, loss = 0.87506743
Iteration 41, loss = 0.86899965
Iteration 42, loss = 0.86302984
Iteration 43, loss = 0.85715601
Iteration 44, loss = 0.85137327
Iteration 45, loss = 0.84567913
Iteration 46, loss = 0.84007378
Iteration 47, loss = 0.83455686
Iteration 48, loss = 0.82912746
Iteration 49, loss = 0.82378323
Iteration 50, loss = 0.81852399
Iteration 51, loss = 0.81334725
Iteration 52, loss = 0.80825215
Iteration 53, loss = 0.80323898
Iteration 54, loss = 0.79830520
Iteration 55, loss = 0.79344878
Iteration 56, loss = 0.78866850
Iteration 57, loss = 0.78396399
Iteration 58, loss = 0.77933321
Iteration 59, loss = 0.77477297
Iteration 60, loss = 0.77028062
Iteration 61, loss = 0.76585707
Iteration 62, loss = 0.76149989
Iteration 63, loss = 0.75720799
Iteration 64, loss = 0.75298054
Iteration 65, loss = 0.74881438
Iteration 66, loss = 0.74470980
Iteration 67, loss = 0.74066525
Iteration 68, loss = 0.73667903
Iteration 69, loss = 0.73275049
Iteration 70, loss = 0.72887778
Iteration 71, loss = 0.72506146
Iteration 72, loss = 0.72129886
Iteration 73, loss = 0.71758921
Iteration 74, loss = 0.71393141
Iteration 75, loss = 0.71032460
Iteration 76, loss = 0.70676816
Iteration 77, loss = 0.70326037
Iteration 78, loss = 0.69980037
Iteration 79, loss = 0.69639112
Iteration 80, loss = 0.69303064
Iteration 81, loss = 0.68971783
Iteration 82, loss = 0.68645070
Iteration 83, loss = 0.68322782
Iteration 84, loss = 0.68004839
Iteration 85, loss = 0.67691190
Iteration 86, loss = 0.67381667
Iteration 87, loss = 0.67076162
Iteration 88, loss = 0.66774502
Iteration 89, loss = 0.66476432
Iteration 90, loss = 0.66182016
Iteration 91, loss = 0.65891282
Iteration 92, loss = 0.65604278
Iteration 93, loss = 0.65320742
Iteration 94, loss = 0.65040717
Iteration 95, loss = 0.64764196
```

```
Iteration 96, loss = 0.64491029
Iteration 97, loss = 0.64221218
Iteration 98, loss = 0.63954715
Iteration 99, loss = 0.63691450
Iteration 100, loss = 0.63431313
Iteration 101, loss = 0.63174239
Iteration 102, loss = 0.62920106
Iteration 103, loss = 0.62668909
Iteration 104, loss = 0.62420659
Iteration 105, loss = 0.62175233
Iteration 106, loss = 0.61932528
Iteration 107, loss = 0.61692630
Iteration 108, loss = 0.61455534
Iteration 109, loss = 0.61221126
Iteration 110, loss = 0.60989342
Iteration 111, loss = 0.60760195
Iteration 112, loss = 0.60533576
Iteration 113, loss = 0.60309449
Iteration 114, loss = 0.60087877
Iteration 115, loss = 0.59868802
Iteration 116, loss = 0.59652166
Iteration 117, loss = 0.59437992
Iteration 118, loss = 0.59226221
Iteration 119, loss = 0.59016822
Iteration 120, loss = 0.58809718
Iteration 121, loss = 0.58604866
Iteration 122, loss = 0.58402253
Iteration 123, loss = 0.58201784
Iteration 124, loss = 0.58003398
Iteration 125, loss = 0.57807119
Iteration 126, loss = 0.57612946
Iteration 127, loss = 0.57420943
Iteration 128, loss = 0.57231059
Iteration 129, loss = 0.57043205
Iteration 130, loss = 0.56857345
Iteration 131, loss = 0.56673471
Iteration 132, loss = 0.56491572
Iteration 133, loss = 0.56311601
Iteration 134, loss = 0.56133528
Iteration 135, loss = 0.55957343
Iteration 136, loss = 0.55783014
Iteration 137, loss = 0.55610535
Iteration 138, loss = 0.55439821
Iteration 139, loss = 0.55270842
Iteration 140, loss = 0.55103601
Iteration 141, loss = 0.54938107
Iteration 142, loss = 0.54774287
Iteration 143, loss = 0.54612096
Iteration 144, loss = 0.54451578
Iteration 145, loss = 0.54292686
Iteration 146, loss = 0.54135366
Iteration 147, loss = 0.53979582
Iteration 148, loss = 0.53825328
Iteration 149, loss = 0.53672609
Iteration 150, loss = 0.53521388
Iteration 151, loss = 0.53371579
Iteration 152, loss = 0.53223186
Iteration 153, loss = 0.53076286
Iteration 154, loss = 0.52930812
Iteration 155, loss = 0.52786753
Iteration 156, loss = 0.52644101
Iteration 157, loss = 0.52502866
Iteration 158, loss = 0.52363003
Iteration 159, loss = 0.52224506
Iteration 160, loss = 0.52087333
Iteration 161, loss = 0.51951459
Iteration 162, loss = 0.51816867
Iteration 163, loss = 0.51683553
Iteration 164, loss = 0.51551496
```

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Iteration 165, loss = 0.51420688
Iteration 166, loss = 0.51291110
Iteration 167, loss = 0.51162764
Iteration 168, loss = 0.51035649
Iteration 169, loss = 0.50909703
Iteration 170, loss = 0.50784917
Iteration 171, loss = 0.50661279
Iteration 172, loss = 0.50538773
Iteration 173, loss = 0.50417410
Iteration 174, loss = 0.50297129
Iteration 175, loss = 0.50177923
Iteration 176, loss = 0.50059792
Iteration 177, loss = 0.49942731
Iteration 178, loss = 0.49826773
Iteration 179, loss = 0.49711854
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Iteration 776, loss = 0.31105886
Iteration 777, loss = 0.31096033
Iteration 778, loss = 0.31086194
Iteration 779, loss = 0.31076372
Training loss did not improve more than tol=0.000100 for 10 consecutive epochs. Sett
ing learning rate to 0.000200
Iteration 780, loss = 0.31066565
Iteration 781, loss = 0.31058253
Iteration 782, loss = 0.31050583
Iteration 783, loss = 0.31043491
```

```
Iteration 784, loss = 0.31036918
Iteration 785, loss = 0.31030812
Iteration 786, loss = 0.31025127
Iteration 787, loss = 0.31019819
Iteration 788, loss = 0.31014852
Iteration 789, loss = 0.31010190
Iteration 790, loss = 0.31005803
Training loss did not improve more than tol=0.000100 for 10 consecutive epochs. Sett
ing learning rate to 0.000040
Iteration 791, loss = 0.31001662
Iteration 792, loss = 0.30998038
Iteration 793, loss = 0.30994738
Iteration 794, loss = 0.30991731
Iteration 795, loss = 0.30988987
Iteration 796, loss = 0.30986479
Iteration 797, loss = 0.30984184
Iteration 798, loss = 0.30982081
Iteration 799, loss = 0.30980150
Iteration 800, loss = 0.30978374
Iteration 801, loss = 0.30976737
Training loss did not improve more than tol=0.000100 for 10 consecutive epochs. Sett
ing learning rate to 0.000008
Iteration 802, loss = 0.30975226
Iteration 803, loss = 0.30973887
Iteration 804, loss = 0.30972673
Iteration 805, loss = 0.30971574
Iteration 806, loss = 0.30970577
Iteration 807, loss = 0.30969672
Iteration 808, loss = 0.30968850
Iteration 809, loss = 0.30968102
Iteration 810, loss = 0.30967422
Iteration 811, loss = 0.30966802
Iteration 812, loss = 0.30966236
Training loss did not improve more than tol=0.000100 for 10 consecutive epochs. Sett
ing learning rate to 0.000002
Iteration 813, loss = 0.30965720
Iteration 814, loss = 0.30965259
Iteration 815, loss = 0.30964842
Iteration 816, loss = 0.30964466
Iteration 817, loss = 0.30964126
Iteration 818, loss = 0.30963818
Iteration 819, loss = 0.30963540
Iteration 820, loss = 0.30963288
Iteration 821, loss = 0.30963059
Iteration 822, loss = 0.30962852
Iteration 823, loss = 0.30962664
Training loss did not improve more than tol=0.000100 for 10 consecutive epochs. Sett
ing learning rate to 0.000000
Iteration 824, loss = 0.30962494
Iteration 825, loss = 0.30962341
Iteration 826, loss = 0.30962203
Iteration 827, loss = 0.30962079
Iteration 828, loss = 0.30961967
Iteration 829, loss = 0.30961865
Iteration 830, loss = 0.30961774
Iteration 831, loss = 0.30961691
Iteration 832, loss = 0.30961616
Iteration 833, loss = 0.30961549
Iteration 834, loss = 0.30961488
Training loss did not improve more than tol=0.000100 for 10 consecutive epochs. Lear
ning rate too small. Stopping.
```

In [82]:
```
predictions2 = model2.predict(test_features)
```

In [87]:
```
matrix2 = confusion_matrix(predictions2, test_target)
```

In [91]:
```
print(matrix2)
```

```
[[ 9  2  4]
 [ 1 17  0]
 [ 1  0 16]]
```

In [92]:
```
print(classification_report(test_target, predictions2))
```

```
              precision    recall  f1-score   support

           0       0.60      0.82      0.69        11
           1       0.94      0.89      0.92        19
           2       0.94      0.80      0.86        20

    accuracy                           0.84        50
   macro avg       0.83      0.84      0.83        50
weighted avg       0.87      0.84      0.85        50
```

Experiment 3:

In [ ]:
```
```

Changing the following paramaters: Hidden Layer: 400 batch_size: auto learning rate: invscaling activation function: relu loss function: max_iter: 500

In [93]:
```
classifier3 = MLPClassifier(hidden_layer_sizes=(400,), max_iter=500,activation = 're
                            random_state=1, batch_size='auto', learning_rate='invscaling
                                learning_rate_init=0.001, verbose=True)
```

In [94]:
```
classifier3
```

Out[94]:
```
MLPClassifier(hidden_layer_sizes=(400,), learning_rate='invscaling',
              max_iter=500, random_state=1, verbose=True)
```

In [95]:
```
model3=classifier3.fit(training_features, training_target)
```

```
Iteration 1, loss = 1.10153023
Iteration 2, loss = 1.06154440
Iteration 3, loss = 1.02302996
Iteration 4, loss = 0.98601220
Iteration 5, loss = 0.95052859
Iteration 6, loss = 0.91656114
Iteration 7, loss = 0.88406839
Iteration 8, loss = 0.85300700
Iteration 9, loss = 0.82334812
Iteration 10, loss = 0.79509936
Iteration 11, loss = 0.76819469
Iteration 12, loss = 0.74260487
Iteration 13, loss = 0.71829438
Iteration 14, loss = 0.69522472
Iteration 15, loss = 0.67335613
Iteration 16, loss = 0.65261876
Iteration 17, loss = 0.63297913
Iteration 18, loss = 0.61438074
Iteration 19, loss = 0.59678478
Iteration 20, loss = 0.58015467
Iteration 21, loss = 0.56443825
Iteration 22, loss = 0.54960219
Iteration 23, loss = 0.53560788
Iteration 24, loss = 0.52240810
Iteration 25, loss = 0.50997362
Iteration 26, loss = 0.49824996
Iteration 27, loss = 0.48720855
Iteration 28, loss = 0.47680517
Iteration 29, loss = 0.46701520
Iteration 30, loss = 0.45779549
Iteration 31, loss = 0.44911059
Iteration 32, loss = 0.44094503
```

```
Iteration 33, loss = 0.43326374
Iteration 34, loss = 0.42603284
Iteration 35, loss = 0.41922137
Iteration 36, loss = 0.41279229
Iteration 37, loss = 0.40671385
Iteration 38, loss = 0.40095390
Iteration 39, loss = 0.39550251
Iteration 40, loss = 0.39032569
Iteration 41, loss = 0.38540144
Iteration 42, loss = 0.38071272
Iteration 43, loss = 0.37623512
Iteration 44, loss = 0.37195345
Iteration 45, loss = 0.36784895
Iteration 46, loss = 0.36391596
Iteration 47, loss = 0.36014150
Iteration 48, loss = 0.35652117
Iteration 49, loss = 0.35304554
Iteration 50, loss = 0.34969845
Iteration 51, loss = 0.34646952
Iteration 52, loss = 0.34335080
Iteration 53, loss = 0.34033050
Iteration 54, loss = 0.33741003
Iteration 55, loss = 0.33458024
Iteration 56, loss = 0.33183174
Iteration 57, loss = 0.32916498
Iteration 58, loss = 0.32657172
Iteration 59, loss = 0.32405266
Iteration 60, loss = 0.32160759
Iteration 61, loss = 0.31923496
Iteration 62, loss = 0.31693322
Iteration 63, loss = 0.31469253
Iteration 64, loss = 0.31251258
Iteration 65, loss = 0.31039224
Iteration 66, loss = 0.30832446
Iteration 67, loss = 0.30630682
Iteration 68, loss = 0.30433694
Iteration 69, loss = 0.30241279
Iteration 70, loss = 0.30053088
Iteration 71, loss = 0.29869310
Iteration 72, loss = 0.29689913
Iteration 73, loss = 0.29514561
Iteration 74, loss = 0.29343321
Iteration 75, loss = 0.29176180
Iteration 76, loss = 0.29013045
Iteration 77, loss = 0.28853296
Iteration 78, loss = 0.28696991
Iteration 79, loss = 0.28543877
Iteration 80, loss = 0.28394109
Iteration 81, loss = 0.28247831
Iteration 82, loss = 0.28104613
Iteration 83, loss = 0.27964807
Iteration 84, loss = 0.27828204
Iteration 85, loss = 0.27694432
Iteration 86, loss = 0.27563291
Iteration 87, loss = 0.27434593
Iteration 88, loss = 0.27308406
Iteration 89, loss = 0.27184705
Iteration 90, loss = 0.27063316
Iteration 91, loss = 0.26944421
Iteration 92, loss = 0.26827917
Iteration 93, loss = 0.26713380
Iteration 94, loss = 0.26600919
Iteration 95, loss = 0.26490430
Iteration 96, loss = 0.26381867
Iteration 97, loss = 0.26275887
Iteration 98, loss = 0.26172167
Iteration 99, loss = 0.26070122
Iteration 100, loss = 0.25970161
Iteration 101, loss = 0.25872284
```

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Iteration 102, loss = 0.25776519
Iteration 103, loss = 0.25683293
Iteration 104, loss = 0.25592086
Iteration 105, loss = 0.25502379
Iteration 106, loss = 0.25414521
Iteration 107, loss = 0.25328634
Iteration 108, loss = 0.25244546
Iteration 109, loss = 0.25162014
Iteration 110, loss = 0.25081080
Iteration 111, loss = 0.25001806
Iteration 112, loss = 0.24924063
Iteration 113, loss = 0.24847878
Iteration 114, loss = 0.24773234
Iteration 115, loss = 0.24700075
Iteration 116, loss = 0.24628312
Iteration 117, loss = 0.24557998
Iteration 118, loss = 0.24489072
Iteration 119, loss = 0.24421621
Iteration 120, loss = 0.24355649
Iteration 121, loss = 0.24290998
Iteration 122, loss = 0.24227633
Iteration 123, loss = 0.24165336
Iteration 124, loss = 0.24104151
Iteration 125, loss = 0.24044064
Iteration 126, loss = 0.23984866
Iteration 127, loss = 0.23926732
Iteration 128, loss = 0.23869684
Iteration 129, loss = 0.23813583
Iteration 130, loss = 0.23758456
Iteration 131, loss = 0.23704196
Iteration 132, loss = 0.23650933
Iteration 133, loss = 0.23598730
Iteration 134, loss = 0.23547663
Iteration 135, loss = 0.23497441
Iteration 136, loss = 0.23447962
Iteration 137, loss = 0.23399235
Iteration 138, loss = 0.23351234
Iteration 139, loss = 0.23303911
Iteration 140, loss = 0.23257254
Iteration 141, loss = 0.23211261
Iteration 142, loss = 0.23165840
Iteration 143, loss = 0.23121234
Iteration 144, loss = 0.23077186
Iteration 145, loss = 0.23033697
Iteration 146, loss = 0.22990848
Iteration 147, loss = 0.22948589
Iteration 148, loss = 0.22906937
Iteration 149, loss = 0.22865800
Iteration 150, loss = 0.22825149
Iteration 151, loss = 0.22784986
Iteration 152, loss = 0.22745294
Iteration 153, loss = 0.22706084
Iteration 154, loss = 0.22667502
Iteration 155, loss = 0.22629286
Iteration 156, loss = 0.22591459
Iteration 157, loss = 0.22554052
Iteration 158, loss = 0.22517021
Iteration 159, loss = 0.22480306
Iteration 160, loss = 0.22443965
Iteration 161, loss = 0.22408120
Iteration 162, loss = 0.22372737
Iteration 163, loss = 0.22337695
Iteration 164, loss = 0.22302955
Iteration 165, loss = 0.22268561
Iteration 166, loss = 0.22234630
Iteration 167, loss = 0.22200966
Iteration 168, loss = 0.22167573
Iteration 169, loss = 0.22134564
Iteration 170, loss = 0.22101915
```

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Iteration 171, loss = 0.22069628
Iteration 172, loss = 0.22037572
Iteration 173, loss = 0.22005740
Iteration 174, loss = 0.21974307
Iteration 175, loss = 0.21943122
Iteration 176, loss = 0.21912167
Iteration 177, loss = 0.21881492
Iteration 178, loss = 0.21851211
Iteration 179, loss = 0.21821111
Iteration 180, loss = 0.21791146
Iteration 181, loss = 0.21761311
Iteration 182, loss = 0.21731684
Iteration 183, loss = 0.21702254
Iteration 184, loss = 0.21673019
Iteration 185, loss = 0.21643921
Iteration 186, loss = 0.21614890
Iteration 187, loss = 0.21586027
Iteration 188, loss = 0.21557356
Iteration 189, loss = 0.21528881
Iteration 190, loss = 0.21500526
Iteration 191, loss = 0.21472272
Iteration 192, loss = 0.21444204
Iteration 193, loss = 0.21416280
Iteration 194, loss = 0.21388597
Iteration 195, loss = 0.21361096
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Iteration 201, loss = 0.21200854
Iteration 202, loss = 0.21174756
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Iteration 204, loss = 0.21122972
Iteration 205, loss = 0.21097356
Iteration 206, loss = 0.21071973
Iteration 207, loss = 0.21046617
Iteration 208, loss = 0.21021341
Iteration 209, loss = 0.20996164
Iteration 210, loss = 0.20971093
Iteration 211, loss = 0.20946017
Iteration 212, loss = 0.20920931
Iteration 213, loss = 0.20895889
Iteration 214, loss = 0.20870940
Iteration 215, loss = 0.20846014
Iteration 216, loss = 0.20821286
Iteration 217, loss = 0.20796609
Iteration 218, loss = 0.20772007
Iteration 219, loss = 0.20747500
Iteration 220, loss = 0.20723265
Iteration 221, loss = 0.20698950
Iteration 222, loss = 0.20674519
Iteration 223, loss = 0.20649930
Iteration 224, loss = 0.20625380
Iteration 225, loss = 0.20600927
Iteration 226, loss = 0.20576498
Iteration 227, loss = 0.20552212
Iteration 228, loss = 0.20528171
Iteration 229, loss = 0.20504057
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Iteration 231, loss = 0.20456268
Iteration 232, loss = 0.20432727
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Iteration 235, loss = 0.20362995
Iteration 236, loss = 0.20339846
Iteration 237, loss = 0.20316909
Iteration 238, loss = 0.20294008
Iteration 239, loss = 0.20271010
```

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Iteration 240, loss = 0.20248050
Iteration 241, loss = 0.20225180
Iteration 242, loss = 0.20202568
Iteration 243, loss = 0.20180100
Iteration 244, loss = 0.20157631
Iteration 245, loss = 0.20135142
Iteration 246, loss = 0.20112706
Iteration 247, loss = 0.20090467
Iteration 248, loss = 0.20068262
Iteration 249, loss = 0.20046196
Iteration 250, loss = 0.20024228
Iteration 251, loss = 0.20002665
Iteration 252, loss = 0.19981316
Iteration 253, loss = 0.19959980
Iteration 254, loss = 0.19938513
Iteration 255, loss = 0.19917008
Iteration 256, loss = 0.19895523
Iteration 257, loss = 0.19874210
Iteration 258, loss = 0.19853010
Iteration 259, loss = 0.19831850
Iteration 260, loss = 0.19810786
Iteration 261, loss = 0.19789782
Iteration 262, loss = 0.19768858
Iteration 263, loss = 0.19747827
Iteration 264, loss = 0.19726904
Iteration 265, loss = 0.19705969
Iteration 266, loss = 0.19684947
Iteration 267, loss = 0.19663949
Iteration 268, loss = 0.19643086
Iteration 269, loss = 0.19622309
Iteration 270, loss = 0.19601441
Iteration 271, loss = 0.19580635
Iteration 272, loss = 0.19560300
Iteration 273, loss = 0.19539908
Iteration 274, loss = 0.19519567
Iteration 275, loss = 0.19499273
Iteration 276, loss = 0.19479041
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Iteration 281, loss = 0.19379155
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Iteration 285, loss = 0.19300771
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Iteration 287, loss = 0.19261805
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Iteration 290, loss = 0.19203685
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Iteration 299, loss = 0.19032496
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Iteration 303, loss = 0.18957361
Iteration 304, loss = 0.18938920
Iteration 305, loss = 0.18920325
Iteration 306, loss = 0.18901737
Iteration 307, loss = 0.18883256
Iteration 308, loss = 0.18864752
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Iteration 309, loss = 0.18846434
Iteration 310, loss = 0.18827989
Iteration 311, loss = 0.18809375
Iteration 312, loss = 0.18790649
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Iteration 314, loss = 0.18753853
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Iteration 317, loss = 0.18698408
Iteration 318, loss = 0.18680225
Iteration 319, loss = 0.18661897
Iteration 320, loss = 0.18643814
Iteration 321, loss = 0.18625829
Iteration 322, loss = 0.18607630
Iteration 323, loss = 0.18589529
Iteration 324, loss = 0.18571543
Iteration 325, loss = 0.18553465
Iteration 326, loss = 0.18535534
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Iteration 354, loss = 0.18046043
Iteration 355, loss = 0.18029256
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Iteration 357, loss = 0.17995970
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Iteration 362, loss = 0.17913072
Iteration 363, loss = 0.17896651
Iteration 364, loss = 0.17880084
Iteration 365, loss = 0.17863565
Iteration 366, loss = 0.17846998
Iteration 367, loss = 0.17830820
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Iteration 369, loss = 0.17799322
Iteration 370, loss = 0.17783866
Iteration 371, loss = 0.17768035
Iteration 372, loss = 0.17752211
Iteration 373, loss = 0.17736672
Iteration 374, loss = 0.17720861
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Iteration 378, loss = 0.17658192
Iteration 379, loss = 0.17642521
Iteration 380, loss = 0.17626828
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Iteration 384, loss = 0.17565470
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Iteration 386, loss = 0.17534982
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Iteration 389, loss = 0.17488939
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Iteration 393, loss = 0.17428696
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Iteration 402, loss = 0.17297878
Iteration 403, loss = 0.17283688
Iteration 404, loss = 0.17269776
Iteration 405, loss = 0.17255416
Iteration 406, loss = 0.17241451
Iteration 407, loss = 0.17227675
Iteration 408, loss = 0.17213692
Iteration 409, loss = 0.17200310
Iteration 410, loss = 0.17186619
Iteration 411, loss = 0.17172875
Iteration 412, loss = 0.17159291
Iteration 413, loss = 0.17145856
Iteration 414, loss = 0.17132366
Iteration 415, loss = 0.17118767
Iteration 416, loss = 0.17105352
Iteration 417, loss = 0.17092028
Iteration 418, loss = 0.17078255
Iteration 419, loss = 0.17064671
Iteration 420, loss = 0.17050683
Iteration 421, loss = 0.17037029
Iteration 422, loss = 0.17022900
Iteration 423, loss = 0.17008491
Iteration 424, loss = 0.16994744
Iteration 425, loss = 0.16980998
Iteration 426, loss = 0.16967632
Iteration 427, loss = 0.16954341
Iteration 428, loss = 0.16940887
Iteration 429, loss = 0.16927467
Iteration 430, loss = 0.16914165
Iteration 431, loss = 0.16901027
Iteration 432, loss = 0.16887773
Iteration 433, loss = 0.16874788
Iteration 434, loss = 0.16861679
Iteration 435, loss = 0.16848046
Iteration 436, loss = 0.16834691
Iteration 437, loss = 0.16821930
Iteration 438, loss = 0.16808843
Iteration 439, loss = 0.16795680
Iteration 440, loss = 0.16782572
Iteration 441, loss = 0.16769990
Iteration 442, loss = 0.16757361
Iteration 443, loss = 0.16744422
Iteration 444, loss = 0.16731290
Iteration 445, loss = 0.16718586
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Iteration 447, loss = 0.16692530
Iteration 448, loss = 0.16679306
Iteration 449, loss = 0.16666296
Iteration 450, loss = 0.16653549
Iteration 451, loss = 0.16640776
Iteration 452, loss = 0.16628304
Iteration 453, loss = 0.16615365
Iteration 454, loss = 0.16602556
Iteration 455, loss = 0.16590206
Iteration 456, loss = 0.16577436
Iteration 457, loss = 0.16564657
Iteration 458, loss = 0.16551934
Iteration 459, loss = 0.16539520
Iteration 460, loss = 0.16527602
Iteration 461, loss = 0.16515222
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Iteration 463, loss = 0.16491176
Iteration 464, loss = 0.16479117
Iteration 465, loss = 0.16466945
Iteration 466, loss = 0.16454894
Iteration 467, loss = 0.16442955
Iteration 468, loss = 0.16431312
Iteration 469, loss = 0.16419302
Iteration 470, loss = 0.16407084
Iteration 471, loss = 0.16394683
Iteration 472, loss = 0.16383105
Iteration 473, loss = 0.16371187
Iteration 474, loss = 0.16359189
Iteration 475, loss = 0.16347419
Iteration 476, loss = 0.16335462
Iteration 477, loss = 0.16323939
Iteration 478, loss = 0.16311963
Iteration 479, loss = 0.16299882
Iteration 480, loss = 0.16288172
Iteration 481, loss = 0.16276756
Iteration 482, loss = 0.16265097
Iteration 483, loss = 0.16253585
Iteration 484, loss = 0.16241817
Iteration 485, loss = 0.16230431
Iteration 486, loss = 0.16219367
Iteration 487, loss = 0.16208182
Iteration 488, loss = 0.16196733
Iteration 489, loss = 0.16185319
Iteration 490, loss = 0.16174161
Iteration 491, loss = 0.16162534
Iteration 492, loss = 0.16151832
Iteration 493, loss = 0.16140766
Iteration 494, loss = 0.16129713
Iteration 495, loss = 0.16118680
Iteration 496, loss = 0.16107222
Iteration 497, loss = 0.16096113
Iteration 498, loss = 0.16084892
Iteration 499, loss = 0.16073973
Iteration 500, loss = 0.16063198
C:\Users\Acer\anaconda3\lib\site-packages\sklearn\neural_network\_multilayer_perceptron.py:582: ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and the optimization hasn't converged yet.
  warnings.warn(
```

In [97]:
```
predictions3 = model3.predict(test_features)
```

In [98]:
```
matrix3 = confusion_matrix(predictions3, test_target)
```

In [99]:
```
print(matrix3)
```

```
[[10  5  3]
 [ 1 14  0]
 [ 0  0 17]]
```

In [100…
```
print(classification_report(test_target, predictions3))
```

```
              precision    recall  f1-score   support

           0       0.56      0.91      0.69        11
           1       0.93      0.74      0.82        19
           2       1.00      0.85      0.92        20

    accuracy                           0.82        50
   macro avg       0.83      0.83      0.81        50
weighted avg       0.88      0.82      0.83        50
```

End Of Assignment!!