Assignment 1 - Deep Learning Fundamentals

In [1]:
```
import pandas as pd
from sklearn.datasets import load_svmlight_file

# Read pre-processed data from file
X, y = load_svmlight_file('diabetes_scale.txt')

# Convert into a dense numpy array
X_dense = X.toarray()

# Create a pandas DataFrame
data = pd.DataFrame(X_dense, columns=[f'Feature_{i}' for i in range(X_dense.shape[1

# Named 'Label' column for the class labels, and changed labels with value of -1 to
data['Label'] = y
data['Label'] = data['Label'].replace(-1,0)
data
```

Out[1]:

	Feature_0	Feature_1	Feature_2	Feature_3	Feature_4	Feature_5	Feature_6	Feature_7	Label
0	-0.294118	0.487437	0.180328	-0.292929	-1.000000	0.001490	-0.531170	-0.033333	0.0
1	-0.882353	-0.145729	0.081967	-0.414141	-1.000000	-0.207153	-0.766866	-0.666667	1.0
2	-0.058824	0.839196	0.049180	-1.000000	-1.000000	-0.305514	-0.492741	-0.633333	0.0
3	-0.882353	-0.105528	0.081967	-0.535354	-0.777778	-0.162444	-0.923997	-1.000000	1.0
4	-1.000000	0.376884	-0.344262	-0.292929	-0.602837	0.284650	0.887276	-0.600000	0.0
...	...	...	...	...	...	...	...	...	..
763	0.176471	0.015075	0.245902	-0.030303	-0.574468	-0.019374	-0.920581	0.400000	1.0
764	-0.764706	0.226131	0.147541	-0.454545	-1.000000	0.096870	-0.776260	-0.800000	1.0
765	-0.411765	0.216080	0.180328	-0.535354	-0.735225	-0.219076	-0.857387	-0.700000	1.0
766	-0.882353	0.266332	-0.016393	-1.000000	-1.000000	-0.102832	-0.768574	-0.133333	0.0
767	-0.882353	-0.065327	0.147541	-0.373737	-1.000000	-0.093890	-0.797609	-0.933333	1.0

768 rows × 9 columns

In [2]:
```
# Split the data into training, validation and testing sets:
from sklearn.model_selection import train_test_split
X_temp, X_test, y_temp, y_test = train_test_split(data.drop('Label', axis=1), data[
X_train, X_val, y_train, y_val = train_test_split(X_temp, y_temp, test_size=0.2)
```

In [3]:
```
# Deep Learning imports
import numpy as np
import tensorflow as tf
from tensorflow import keras
# Define some key parameters
hiddensizes = [16,32,64,128]
actfn = "relu"
# Optimiser and learning rate
opt_ins = keras.optimizers.Adam
learningrate = 0.001
```

```
# Set size of batch and number of epochs
batch_size = 32
n_epochs = 50
```

In [4]:
```
# Build Perceptron model (using dense layers)
def perceptron(hiddensizes, actfn, optimizer, learningrate):
    model = keras.models.Sequential()
    model.add(keras.layers.Dense(8, activation = actfn))
    for n in hiddensizes:
        model.add(keras.layers.Dense(n, activation = actfn))
    model.add(keras.layers.Dense(1, activation = 'sigmoid'))
    model.compile(loss="binary_crossentropy", optimizer=optimizer(learning_rate=lea
    return model

def implement(hiddensizes, actfn, optimizer, learningrate, n_epochs, batch_size):
    model = perceptron(hiddensizes, actfn, optimizer, learningrate)
    history = model.fit(X_train, y_train, epochs=n_epochs, validation_data=(X_val,
    max_val_acc = np.max(history.history['val_accuracy'])
    return (max_val_acc, history, model)

def plot_history(history):
    plt.figure(figsize=(8,5))
    n = len(history.history['accuracy'])
    plt.plot(np.arange(0,n),history.history['accuracy'], color='orange')
    plt.plot(np.arange(0,n),history.history['loss'],'b')
    plt.plot(np.arange(0,n)+0.5,history.history['val_accuracy'],'r')
    plt.plot(np.arange(0,n)+0.5,history.history['val_loss'],'g')
    plt.legend(['Train Acc','Train Loss','Val Acc','Val Loss'])
    plt.grid(True)
    plt.show()
```

In [5]:
```
# Training
val_acc, history, model_trained = implement(hiddensizes, actfn, opt_ins, learningra
print("Best accuracy: ", val_acc)
```

```
Epoch 1/50
16/16 [==============================] - 1s 9ms/step - loss: 0.6727 - accuracy: 0.
6375 - val_loss: 0.6469 - val_accuracy: 0.6667
Epoch 2/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6410 - accuracy: 0.
6456 - val_loss: 0.6230 - val_accuracy: 0.6667
Epoch 3/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6216 - accuracy: 0.
6456 - val_loss: 0.6005 - val_accuracy: 0.6667
Epoch 4/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6039 - accuracy: 0.
6578 - val_loss: 0.5737 - val_accuracy: 0.6585
Epoch 5/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5841 - accuracy: 0.
6843 - val_loss: 0.5625 - val_accuracy: 0.6911
Epoch 6/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5736 - accuracy: 0.
6904 - val_loss: 0.5495 - val_accuracy: 0.6748
Epoch 7/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5607 - accuracy: 0.
7189 - val_loss: 0.5395 - val_accuracy: 0.6748
Epoch 8/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5532 - accuracy: 0.
7088 - val_loss: 0.5408 - val_accuracy: 0.6667
Epoch 9/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5445 - accuracy: 0.
7088 - val_loss: 0.5340 - val_accuracy: 0.7398
Epoch 10/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5343 - accuracy: 0.
7251 - val_loss: 0.5294 - val_accuracy: 0.7154
Epoch 11/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5311 - accuracy: 0.
7434 - val_loss: 0.5238 - val_accuracy: 0.7398
Epoch 12/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5216 - accuracy: 0.
7434 - val_loss: 0.5218 - val_accuracy: 0.7317
Epoch 13/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5164 - accuracy: 0.
7291 - val_loss: 0.5236 - val_accuracy: 0.7236
Epoch 14/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5093 - accuracy: 0.
7413 - val_loss: 0.5127 - val_accuracy: 0.7317
Epoch 15/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4995 - accuracy: 0.
7576 - val_loss: 0.5122 - val_accuracy: 0.7317
Epoch 16/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4953 - accuracy: 0.
7495 - val_loss: 0.5251 - val_accuracy: 0.7561
Epoch 17/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4947 - accuracy: 0.
7413 - val_loss: 0.5063 - val_accuracy: 0.7317
Epoch 18/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4853 - accuracy: 0.
7658 - val_loss: 0.5067 - val_accuracy: 0.7480
Epoch 19/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4823 - accuracy: 0.
7637 - val_loss: 0.5036 - val_accuracy: 0.7561
Epoch 20/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4834 - accuracy: 0.
7536 - val_loss: 0.5111 - val_accuracy: 0.7642
Epoch 21/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4751 - accuracy: 0.
7617 - val_loss: 0.5030 - val_accuracy: 0.7236
Epoch 22/50
```

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16/16 [==============================] - 0s 2ms/step - loss: 0.4704 - accuracy: 0.
7637 - val_loss: 0.5099 - val_accuracy: 0.7724
Epoch 23/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4616 - accuracy: 0.
7821 - val_loss: 0.5058 - val_accuracy: 0.7073
Epoch 24/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4557 - accuracy: 0.
7882 - val_loss: 0.5085 - val_accuracy: 0.7642
Epoch 25/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4619 - accuracy: 0.
7699 - val_loss: 0.5276 - val_accuracy: 0.7642
Epoch 26/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4553 - accuracy: 0.
7780 - val_loss: 0.5093 - val_accuracy: 0.7642
Epoch 27/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4457 - accuracy: 0.
7739 - val_loss: 0.5140 - val_accuracy: 0.7317
Epoch 28/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4459 - accuracy: 0.
7780 - val_loss: 0.5234 - val_accuracy: 0.7642
Epoch 29/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4520 - accuracy: 0.
7821 - val_loss: 0.5453 - val_accuracy: 0.7561
Epoch 30/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4384 - accuracy: 0.
7963 - val_loss: 0.5267 - val_accuracy: 0.7317
Epoch 31/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4454 - accuracy: 0.
7882 - val_loss: 0.5178 - val_accuracy: 0.7642
Epoch 32/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4847 - accuracy: 0.
7658 - val_loss: 0.6284 - val_accuracy: 0.6992
Epoch 33/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4626 - accuracy: 0.
7617 - val_loss: 0.5187 - val_accuracy: 0.7480
Epoch 34/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4302 - accuracy: 0.
7963 - val_loss: 0.5208 - val_accuracy: 0.7642
Epoch 35/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4314 - accuracy: 0.
7902 - val_loss: 0.5206 - val_accuracy: 0.7642
Epoch 36/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4475 - accuracy: 0.
7821 - val_loss: 0.5205 - val_accuracy: 0.7561
Epoch 37/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4383 - accuracy: 0.
7963 - val_loss: 0.5191 - val_accuracy: 0.7480
Epoch 38/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4304 - accuracy: 0.
7841 - val_loss: 0.5283 - val_accuracy: 0.7642
Epoch 39/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4167 - accuracy: 0.
7963 - val_loss: 0.5237 - val_accuracy: 0.7805
Epoch 40/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4160 - accuracy: 0.
7943 - val_loss: 0.5326 - val_accuracy: 0.7724
Epoch 41/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4137 - accuracy: 0.
8004 - val_loss: 0.5306 - val_accuracy: 0.7724
Epoch 42/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4138 - accuracy: 0.
7943 - val_loss: 0.5354 - val_accuracy: 0.7642
Epoch 43/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4084 - accuracy: 0.
```

```
8045 - val_loss: 0.5462 - val_accuracy: 0.7398
Epoch 44/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4197 - accuracy: 0.
7943 - val_loss: 0.5409 - val_accuracy: 0.7642
Epoch 45/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4080 - accuracy: 0.
8024 - val_loss: 0.5495 - val_accuracy: 0.7642
Epoch 46/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4057 - accuracy: 0.
8004 - val_loss: 0.5438 - val_accuracy: 0.7642
Epoch 47/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4074 - accuracy: 0.
7963 - val_loss: 0.5552 - val_accuracy: 0.7724
Epoch 48/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4122 - accuracy: 0.
8065 - val_loss: 0.5366 - val_accuracy: 0.7561
Epoch 49/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4006 - accuracy: 0.
8208 - val_loss: 0.5627 - val_accuracy: 0.7642
Epoch 50/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4220 - accuracy: 0.
8004 - val_loss: 0.5576 - val_accuracy: 0.7805
Best accuracy:  0.7804877758026123
```

In [6]:

```
# To plot nice figures
%matplotlib inline
import matplotlib as mpl
import matplotlib.pyplot as plt
mpl.rc('axes', labelsize=14)
mpl.rc('xtick', labelsize=12)
mpl.rc('ytick', labelsize=12)
mpl.rc('figure', dpi=100)
import seaborn as sns; sns.set()
res = []
for n in [1,2,3,4]:
    valacc, history, discard = implement(hiddensizes[:n], actfn, opt_ins, learningr
    res += [[n,valacc]]

print('Model perfomance of different number of hidden layers:')
print(res)
res=np.array(res)
plt.plot(res[:,0],res[:,1])
plt.plot(res[:,0],res[:,1],'o')
plt.title('Accuracy vs Layers')
plt.xlabel('Number of Layers')
plt.ylabel('Val Accuracy')
```

```
Epoch 1/50
16/16 [==============================] - 0s 6ms/step - loss: 0.7015 - accuracy: 0.
3971 - val_loss: 0.6905 - val_accuracy: 0.6585
Epoch 2/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6767 - accuracy: 0.
6701 - val_loss: 0.6651 - val_accuracy: 0.6504
Epoch 3/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6568 - accuracy: 0.
6558 - val_loss: 0.6441 - val_accuracy: 0.6667
Epoch 4/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6417 - accuracy: 0.
6538 - val_loss: 0.6268 - val_accuracy: 0.6667
Epoch 5/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6288 - accuracy: 0.
6477 - val_loss: 0.6147 - val_accuracy: 0.6667
Epoch 6/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6195 - accuracy: 0.
6456 - val_loss: 0.6073 - val_accuracy: 0.6667
Epoch 7/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6132 - accuracy: 0.
6456 - val_loss: 0.6007 - val_accuracy: 0.6585
Epoch 8/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6077 - accuracy: 0.
6497 - val_loss: 0.5956 - val_accuracy: 0.6585
Epoch 9/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6023 - accuracy: 0.
6497 - val_loss: 0.5904 - val_accuracy: 0.6585
Epoch 10/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5968 - accuracy: 0.
6497 - val_loss: 0.5859 - val_accuracy: 0.6748
Epoch 11/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5914 - accuracy: 0.
6599 - val_loss: 0.5809 - val_accuracy: 0.6829
Epoch 12/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5857 - accuracy: 0.
6619 - val_loss: 0.5754 - val_accuracy: 0.6911
Epoch 13/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5794 - accuracy: 0.
6701 - val_loss: 0.5712 - val_accuracy: 0.6748
Epoch 14/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5735 - accuracy: 0.
6741 - val_loss: 0.5649 - val_accuracy: 0.6748
Epoch 15/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5667 - accuracy: 0.
6843 - val_loss: 0.5598 - val_accuracy: 0.6829
Epoch 16/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5594 - accuracy: 0.
6986 - val_loss: 0.5538 - val_accuracy: 0.6748
Epoch 17/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5535 - accuracy: 0.
6986 - val_loss: 0.5484 - val_accuracy: 0.6748
Epoch 18/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5476 - accuracy: 0.
6986 - val_loss: 0.5431 - val_accuracy: 0.6992
Epoch 19/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5424 - accuracy: 0.
7047 - val_loss: 0.5384 - val_accuracy: 0.7317
Epoch 20/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5356 - accuracy: 0.
7189 - val_loss: 0.5324 - val_accuracy: 0.7317
Epoch 21/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5300 - accuracy: 0.
7189 - val_loss: 0.5276 - val_accuracy: 0.7398
Epoch 22/50
```

```
16/16 [==============================] - 0s 2ms/step - loss: 0.5236 - accuracy: 0.
7312 - val_loss: 0.5238 - val_accuracy: 0.7561
Epoch 23/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5178 - accuracy: 0.
7495 - val_loss: 0.5210 - val_accuracy: 0.7561
Epoch 24/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5126 - accuracy: 0.
7658 - val_loss: 0.5188 - val_accuracy: 0.7480
Epoch 25/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5076 - accuracy: 0.
7658 - val_loss: 0.5159 - val_accuracy: 0.7480
Epoch 26/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5032 - accuracy: 0.
7658 - val_loss: 0.5129 - val_accuracy: 0.7480
Epoch 27/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4994 - accuracy: 0.
7739 - val_loss: 0.5105 - val_accuracy: 0.7480
Epoch 28/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4962 - accuracy: 0.
7800 - val_loss: 0.5083 - val_accuracy: 0.7480
Epoch 29/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4922 - accuracy: 0.
7780 - val_loss: 0.5073 - val_accuracy: 0.7480
Epoch 30/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4888 - accuracy: 0.
7780 - val_loss: 0.5065 - val_accuracy: 0.7317
Epoch 31/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4868 - accuracy: 0.
7800 - val_loss: 0.5069 - val_accuracy: 0.7398
Epoch 32/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4845 - accuracy: 0.
7800 - val_loss: 0.5037 - val_accuracy: 0.7480
Epoch 33/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4820 - accuracy: 0.
7862 - val_loss: 0.5028 - val_accuracy: 0.7480
Epoch 34/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4808 - accuracy: 0.
7780 - val_loss: 0.5014 - val_accuracy: 0.7480
Epoch 35/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4775 - accuracy: 0.
7821 - val_loss: 0.4992 - val_accuracy: 0.7480
Epoch 36/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4748 - accuracy: 0.
7862 - val_loss: 0.4995 - val_accuracy: 0.7480
Epoch 37/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4731 - accuracy: 0.
7882 - val_loss: 0.4990 - val_accuracy: 0.7561
Epoch 38/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4716 - accuracy: 0.
7882 - val_loss: 0.4975 - val_accuracy: 0.7480
Epoch 39/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4701 - accuracy: 0.
7902 - val_loss: 0.4965 - val_accuracy: 0.7480
Epoch 40/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4680 - accuracy: 0.
7902 - val_loss: 0.4967 - val_accuracy: 0.7480
Epoch 41/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4662 - accuracy: 0.
7841 - val_loss: 0.4962 - val_accuracy: 0.7642
Epoch 42/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4647 - accuracy: 0.
7862 - val_loss: 0.4980 - val_accuracy: 0.7642
Epoch 43/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4622 - accuracy: 0.
```

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7882 - val_loss: 0.4961 - val_accuracy: 0.7642
Epoch 44/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4617 - accuracy: 0.
7923 - val_loss: 0.4966 - val_accuracy: 0.7642
Epoch 45/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4604 - accuracy: 0.
7902 - val_loss: 0.4970 - val_accuracy: 0.7724
Epoch 46/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4599 - accuracy: 0.
7902 - val_loss: 0.4974 - val_accuracy: 0.7561
Epoch 47/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4596 - accuracy: 0.
7923 - val_loss: 0.4972 - val_accuracy: 0.7724
Epoch 48/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4590 - accuracy: 0.
7882 - val_loss: 0.4980 - val_accuracy: 0.7642
Epoch 49/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4589 - accuracy: 0.
7923 - val_loss: 0.4978 - val_accuracy: 0.7724
Epoch 50/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4570 - accuracy: 0.
7882 - val_loss: 0.4994 - val_accuracy: 0.7724
Epoch 1/50
16/16 [==============================] - 0s 7ms/step - loss: 0.6901 - accuracy: 0.
5580 - val_loss: 0.6774 - val_accuracy: 0.6585
Epoch 2/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6610 - accuracy: 0.
6599 - val_loss: 0.6504 - val_accuracy: 0.6504
Epoch 3/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6383 - accuracy: 0.
6578 - val_loss: 0.6277 - val_accuracy: 0.6585
Epoch 4/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6166 - accuracy: 0.
6599 - val_loss: 0.6060 - val_accuracy: 0.6829
Epoch 5/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5973 - accuracy: 0.
6843 - val_loss: 0.5851 - val_accuracy: 0.6992
Epoch 6/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5776 - accuracy: 0.
7047 - val_loss: 0.5659 - val_accuracy: 0.6911
Epoch 7/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5586 - accuracy: 0.
7210 - val_loss: 0.5500 - val_accuracy: 0.7317
Epoch 8/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5437 - accuracy: 0.
7475 - val_loss: 0.5342 - val_accuracy: 0.7480
Epoch 9/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5308 - accuracy: 0.
7332 - val_loss: 0.5223 - val_accuracy: 0.7561
Epoch 10/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5211 - accuracy: 0.
7597 - val_loss: 0.5129 - val_accuracy: 0.7561
Epoch 11/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5162 - accuracy: 0.
7597 - val_loss: 0.5066 - val_accuracy: 0.7561
Epoch 12/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5154 - accuracy: 0.
7413 - val_loss: 0.5034 - val_accuracy: 0.7561
Epoch 13/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5045 - accuracy: 0.
7658 - val_loss: 0.5002 - val_accuracy: 0.7561
Epoch 14/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5008 - accuracy: 0.
7617 - val_loss: 0.4969 - val_accuracy: 0.7642
```

```
Epoch 15/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4975 - accuracy: 0.
7678 - val_loss: 0.4948 - val_accuracy: 0.7642
Epoch 16/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4954 - accuracy: 0.
7678 - val_loss: 0.4943 - val_accuracy: 0.7642
Epoch 17/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4907 - accuracy: 0.
7678 - val_loss: 0.4948 - val_accuracy: 0.7642
Epoch 18/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4914 - accuracy: 0.
7699 - val_loss: 0.4928 - val_accuracy: 0.7642
Epoch 19/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4878 - accuracy: 0.
7719 - val_loss: 0.4912 - val_accuracy: 0.7724
Epoch 20/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4850 - accuracy: 0.
7739 - val_loss: 0.4919 - val_accuracy: 0.7642
Epoch 21/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4829 - accuracy: 0.
7780 - val_loss: 0.4904 - val_accuracy: 0.7805
Epoch 22/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4845 - accuracy: 0.
7739 - val_loss: 0.4894 - val_accuracy: 0.7886
Epoch 23/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4796 - accuracy: 0.
7780 - val_loss: 0.4902 - val_accuracy: 0.7805
Epoch 24/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4753 - accuracy: 0.
7841 - val_loss: 0.4909 - val_accuracy: 0.7886
Epoch 25/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4743 - accuracy: 0.
7800 - val_loss: 0.4909 - val_accuracy: 0.7724
Epoch 26/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4740 - accuracy: 0.
7739 - val_loss: 0.4924 - val_accuracy: 0.7642
Epoch 27/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4694 - accuracy: 0.
7739 - val_loss: 0.4953 - val_accuracy: 0.7724
Epoch 28/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4673 - accuracy: 0.
7739 - val_loss: 0.4945 - val_accuracy: 0.7561
Epoch 29/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4679 - accuracy: 0.
7780 - val_loss: 0.4928 - val_accuracy: 0.7561
Epoch 30/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4642 - accuracy: 0.
7780 - val_loss: 0.4932 - val_accuracy: 0.7642
Epoch 31/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4640 - accuracy: 0.
7780 - val_loss: 0.4956 - val_accuracy: 0.7724
Epoch 32/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4582 - accuracy: 0.
7841 - val_loss: 0.4944 - val_accuracy: 0.7724
Epoch 33/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4566 - accuracy: 0.
7902 - val_loss: 0.4956 - val_accuracy: 0.7561
Epoch 34/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4547 - accuracy: 0.
7902 - val_loss: 0.4925 - val_accuracy: 0.7642
Epoch 35/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4529 - accuracy: 0.
7862 - val_loss: 0.4935 - val_accuracy: 0.7642
Epoch 36/50
```

```
16/16 [==============================] - 0s 2ms/step - loss: 0.4511 - accuracy: 0.
7943 - val_loss: 0.4954 - val_accuracy: 0.7642
Epoch 37/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4500 - accuracy: 0.
7841 - val_loss: 0.4960 - val_accuracy: 0.7642
Epoch 38/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4487 - accuracy: 0.
7943 - val_loss: 0.4926 - val_accuracy: 0.7642
Epoch 39/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4463 - accuracy: 0.
7963 - val_loss: 0.4955 - val_accuracy: 0.7642
Epoch 40/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4457 - accuracy: 0.
7963 - val_loss: 0.4938 - val_accuracy: 0.7724
Epoch 41/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4446 - accuracy: 0.
7963 - val_loss: 0.4939 - val_accuracy: 0.7642
Epoch 42/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4467 - accuracy: 0.
7902 - val_loss: 0.4966 - val_accuracy: 0.7642
Epoch 43/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4432 - accuracy: 0.
8024 - val_loss: 0.4976 - val_accuracy: 0.7642
Epoch 44/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4454 - accuracy: 0.
7882 - val_loss: 0.4996 - val_accuracy: 0.7642
Epoch 45/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4444 - accuracy: 0.
7923 - val_loss: 0.4974 - val_accuracy: 0.7561
Epoch 46/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4414 - accuracy: 0.
7984 - val_loss: 0.5003 - val_accuracy: 0.7642
Epoch 47/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4414 - accuracy: 0.
7943 - val_loss: 0.5005 - val_accuracy: 0.7561
Epoch 48/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4364 - accuracy: 0.
7984 - val_loss: 0.4986 - val_accuracy: 0.7642
Epoch 49/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4357 - accuracy: 0.
8065 - val_loss: 0.4976 - val_accuracy: 0.7642
Epoch 50/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4381 - accuracy: 0.
8045 - val_loss: 0.4985 - val_accuracy: 0.7642
Epoch 1/50
16/16 [==============================] - 1s 7ms/step - loss: 0.6794 - accuracy: 0.
6191 - val_loss: 0.6520 - val_accuracy: 0.6667
Epoch 2/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6461 - accuracy: 0.
6456 - val_loss: 0.6150 - val_accuracy: 0.6667
Epoch 3/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6220 - accuracy: 0.
6456 - val_loss: 0.5874 - val_accuracy: 0.6667
Epoch 4/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5999 - accuracy: 0.
6456 - val_loss: 0.5682 - val_accuracy: 0.6667
Epoch 5/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5791 - accuracy: 0.
6538 - val_loss: 0.5430 - val_accuracy: 0.6911
Epoch 6/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5545 - accuracy: 0.
6925 - val_loss: 0.5152 - val_accuracy: 0.7642
Epoch 7/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5310 - accuracy: 0.
```

```
7108 - val_loss: 0.4993 - val_accuracy: 0.7805
Epoch 8/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5163 - accuracy: 0.
7271 - val_loss: 0.4894 - val_accuracy: 0.7886
Epoch 9/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5048 - accuracy: 0.
7169 - val_loss: 0.4824 - val_accuracy: 0.7886
Epoch 10/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4953 - accuracy: 0.
7352 - val_loss: 0.4760 - val_accuracy: 0.8049
Epoch 11/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4888 - accuracy: 0.
7434 - val_loss: 0.4737 - val_accuracy: 0.8130
Epoch 12/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4840 - accuracy: 0.
7434 - val_loss: 0.4722 - val_accuracy: 0.7967
Epoch 13/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4795 - accuracy: 0.
7495 - val_loss: 0.4715 - val_accuracy: 0.7724
Epoch 14/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4796 - accuracy: 0.
7515 - val_loss: 0.4759 - val_accuracy: 0.8049
Epoch 15/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4764 - accuracy: 0.
7617 - val_loss: 0.4746 - val_accuracy: 0.7724
Epoch 16/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4793 - accuracy: 0.
7637 - val_loss: 0.4807 - val_accuracy: 0.7967
Epoch 17/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4734 - accuracy: 0.
7637 - val_loss: 0.4761 - val_accuracy: 0.7724
Epoch 18/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4754 - accuracy: 0.
7760 - val_loss: 0.4772 - val_accuracy: 0.8049
Epoch 19/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4729 - accuracy: 0.
7617 - val_loss: 0.4800 - val_accuracy: 0.8049
Epoch 20/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4657 - accuracy: 0.
7739 - val_loss: 0.4782 - val_accuracy: 0.7886
Epoch 21/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4666 - accuracy: 0.
7739 - val_loss: 0.4804 - val_accuracy: 0.7967
Epoch 22/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4689 - accuracy: 0.
7821 - val_loss: 0.4792 - val_accuracy: 0.7805
Epoch 23/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4620 - accuracy: 0.
7780 - val_loss: 0.4833 - val_accuracy: 0.7967
Epoch 24/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4622 - accuracy: 0.
7780 - val_loss: 0.4810 - val_accuracy: 0.7967
Epoch 25/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4622 - accuracy: 0.
7699 - val_loss: 0.4845 - val_accuracy: 0.7805
Epoch 26/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4663 - accuracy: 0.
7760 - val_loss: 0.4843 - val_accuracy: 0.7805
Epoch 27/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4625 - accuracy: 0.
7841 - val_loss: 0.4901 - val_accuracy: 0.8049
Epoch 28/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4603 - accuracy: 0.
7760 - val_loss: 0.4840 - val_accuracy: 0.7967
```

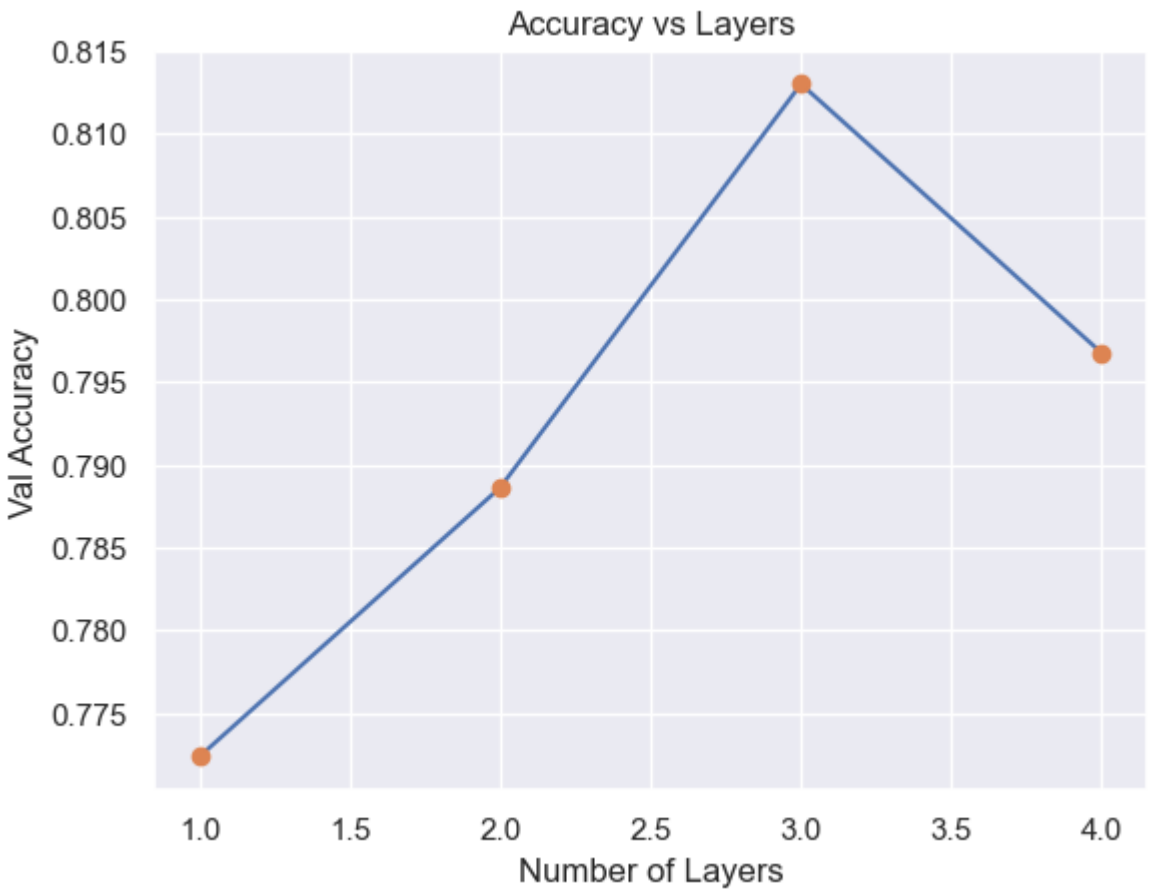
```
Epoch 29/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4530 - accuracy: 0.
7800 - val_loss: 0.4892 - val_accuracy: 0.7724
Epoch 30/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4531 - accuracy: 0.
7841 - val_loss: 0.4862 - val_accuracy: 0.7967
Epoch 31/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4514 - accuracy: 0.
7821 - val_loss: 0.4892 - val_accuracy: 0.7886
Epoch 32/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4493 - accuracy: 0.
7862 - val_loss: 0.4915 - val_accuracy: 0.7886
Epoch 33/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4480 - accuracy: 0.
7862 - val_loss: 0.4929 - val_accuracy: 0.7886
Epoch 34/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4518 - accuracy: 0.
7800 - val_loss: 0.4947 - val_accuracy: 0.7805
Epoch 35/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4452 - accuracy: 0.
7862 - val_loss: 0.4914 - val_accuracy: 0.7724
Epoch 36/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4445 - accuracy: 0.
7862 - val_loss: 0.4953 - val_accuracy: 0.7724
Epoch 37/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4398 - accuracy: 0.
7862 - val_loss: 0.4929 - val_accuracy: 0.7642
Epoch 38/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4370 - accuracy: 0.
7841 - val_loss: 0.4956 - val_accuracy: 0.7642
Epoch 39/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4371 - accuracy: 0.
7862 - val_loss: 0.5001 - val_accuracy: 0.7642
Epoch 40/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4373 - accuracy: 0.
7902 - val_loss: 0.5002 - val_accuracy: 0.7642
Epoch 41/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4332 - accuracy: 0.
7882 - val_loss: 0.5020 - val_accuracy: 0.7642
Epoch 42/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4335 - accuracy: 0.
7943 - val_loss: 0.5009 - val_accuracy: 0.7805
Epoch 43/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4300 - accuracy: 0.
8004 - val_loss: 0.5019 - val_accuracy: 0.7642
Epoch 44/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4272 - accuracy: 0.
7963 - val_loss: 0.5042 - val_accuracy: 0.7805
Epoch 45/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4290 - accuracy: 0.
8004 - val_loss: 0.5098 - val_accuracy: 0.7805
Epoch 46/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4250 - accuracy: 0.
8004 - val_loss: 0.5078 - val_accuracy: 0.7561
Epoch 47/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4176 - accuracy: 0.
8086 - val_loss: 0.5129 - val_accuracy: 0.7642
Epoch 48/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4167 - accuracy: 0.
8147 - val_loss: 0.5176 - val_accuracy: 0.7724
Epoch 49/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4156 - accuracy: 0.
8167 - val_loss: 0.5146 - val_accuracy: 0.7642
Epoch 50/50
```

```
16/16 [==============================] - 0s 2ms/step - loss: 0.4170 - accuracy: 0.
8167 - val_loss: 0.5195 - val_accuracy: 0.7724
Epoch 1/50
16/16 [==============================] - 1s 7ms/step - loss: 0.6634 - accuracy: 0.
5988 - val_loss: 0.6187 - val_accuracy: 0.6667
Epoch 2/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6057 - accuracy: 0.
6477 - val_loss: 0.5766 - val_accuracy: 0.6992
Epoch 3/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5768 - accuracy: 0.
6945 - val_loss: 0.5424 - val_accuracy: 0.7724
Epoch 4/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5459 - accuracy: 0.
7312 - val_loss: 0.5162 - val_accuracy: 0.7805
Epoch 5/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5307 - accuracy: 0.
7332 - val_loss: 0.5045 - val_accuracy: 0.7805
Epoch 6/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5180 - accuracy: 0.
7434 - val_loss: 0.5114 - val_accuracy: 0.7805
Epoch 7/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5138 - accuracy: 0.
7434 - val_loss: 0.5032 - val_accuracy: 0.7805
Epoch 8/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5092 - accuracy: 0.
7536 - val_loss: 0.5010 - val_accuracy: 0.7805
Epoch 9/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4973 - accuracy: 0.
7536 - val_loss: 0.4992 - val_accuracy: 0.7724
Epoch 10/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4961 - accuracy: 0.
7576 - val_loss: 0.4932 - val_accuracy: 0.7805
Epoch 11/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4871 - accuracy: 0.
7637 - val_loss: 0.4931 - val_accuracy: 0.7886
Epoch 12/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4802 - accuracy: 0.
7719 - val_loss: 0.4918 - val_accuracy: 0.7805
Epoch 13/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4752 - accuracy: 0.
7760 - val_loss: 0.4957 - val_accuracy: 0.7561
Epoch 14/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4779 - accuracy: 0.
7780 - val_loss: 0.5072 - val_accuracy: 0.7398
Epoch 15/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4678 - accuracy: 0.
7699 - val_loss: 0.5025 - val_accuracy: 0.7642
Epoch 16/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4645 - accuracy: 0.
7862 - val_loss: 0.5020 - val_accuracy: 0.7642
Epoch 17/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4639 - accuracy: 0.
7800 - val_loss: 0.5062 - val_accuracy: 0.7642
Epoch 18/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4603 - accuracy: 0.
7760 - val_loss: 0.5033 - val_accuracy: 0.7642
Epoch 19/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4722 - accuracy: 0.
7800 - val_loss: 0.5037 - val_accuracy: 0.7724
Epoch 20/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4781 - accuracy: 0.
7719 - val_loss: 0.5090 - val_accuracy: 0.7805
Epoch 21/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4631 - accuracy: 0.
```

```
7862 - val_loss: 0.5101 - val_accuracy: 0.7724
Epoch 22/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4602 - accuracy: 0.
7923 - val_loss: 0.5058 - val_accuracy: 0.7724
Epoch 23/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4529 - accuracy: 0.
7862 - val_loss: 0.5086 - val_accuracy: 0.7805
Epoch 24/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4496 - accuracy: 0.
7923 - val_loss: 0.5075 - val_accuracy: 0.7642
Epoch 25/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4538 - accuracy: 0.
7841 - val_loss: 0.5169 - val_accuracy: 0.7724
Epoch 26/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4498 - accuracy: 0.
7862 - val_loss: 0.5179 - val_accuracy: 0.7886
Epoch 27/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4450 - accuracy: 0.
7984 - val_loss: 0.5101 - val_accuracy: 0.7805
Epoch 28/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4453 - accuracy: 0.
7902 - val_loss: 0.5161 - val_accuracy: 0.7805
Epoch 29/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4434 - accuracy: 0.
7984 - val_loss: 0.5283 - val_accuracy: 0.7642
Epoch 30/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4570 - accuracy: 0.
7923 - val_loss: 0.5100 - val_accuracy: 0.7724
Epoch 31/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4456 - accuracy: 0.
7963 - val_loss: 0.5134 - val_accuracy: 0.7805
Epoch 32/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4447 - accuracy: 0.
8045 - val_loss: 0.5170 - val_accuracy: 0.7886
Epoch 33/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4363 - accuracy: 0.
7984 - val_loss: 0.5176 - val_accuracy: 0.7805
Epoch 34/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4340 - accuracy: 0.
8004 - val_loss: 0.5248 - val_accuracy: 0.7967
Epoch 35/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4371 - accuracy: 0.
7963 - val_loss: 0.5330 - val_accuracy: 0.7805
Epoch 36/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4334 - accuracy: 0.
8024 - val_loss: 0.5392 - val_accuracy: 0.7561
Epoch 37/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4337 - accuracy: 0.
8024 - val_loss: 0.5163 - val_accuracy: 0.7642
Epoch 38/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4267 - accuracy: 0.
8024 - val_loss: 0.5261 - val_accuracy: 0.7805
Epoch 39/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4330 - accuracy: 0.
8167 - val_loss: 0.5206 - val_accuracy: 0.7724
Epoch 40/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4378 - accuracy: 0.
8065 - val_loss: 0.5323 - val_accuracy: 0.7886
Epoch 41/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4250 - accuracy: 0.
8086 - val_loss: 0.5227 - val_accuracy: 0.7805
Epoch 42/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4340 - accuracy: 0.
8086 - val_loss: 0.5300 - val_accuracy: 0.7886
```

```
Epoch 43/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4199 - accuracy: 0.
8187 - val_loss: 0.5330 - val_accuracy: 0.7642
Epoch 44/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4185 - accuracy: 0.
8126 - val_loss: 0.5268 - val_accuracy: 0.7724
Epoch 45/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4185 - accuracy: 0.
8167 - val_loss: 0.5391 - val_accuracy: 0.7642
Epoch 46/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4160 - accuracy: 0.
8187 - val_loss: 0.5426 - val_accuracy: 0.7642
Epoch 47/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4238 - accuracy: 0.
8086 - val_loss: 0.5405 - val_accuracy: 0.7642
Epoch 48/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4176 - accuracy: 0.
8269 - val_loss: 0.5305 - val_accuracy: 0.7805
Epoch 49/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4126 - accuracy: 0.
8167 - val_loss: 0.5329 - val_accuracy: 0.7561
Epoch 50/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4083 - accuracy: 0.
8187 - val_loss: 0.5409 - val_accuracy: 0.7724
Model perfomance of different number of hidden layers:
[[1, 0.772357702255249], [2, 0.7886179089546204], [3, 0.8130081295967102], [4, 0.7
967479825019836]]
Text(0, 0.5, 'Val Accuracy')
```

Out[6]:



In [7]:

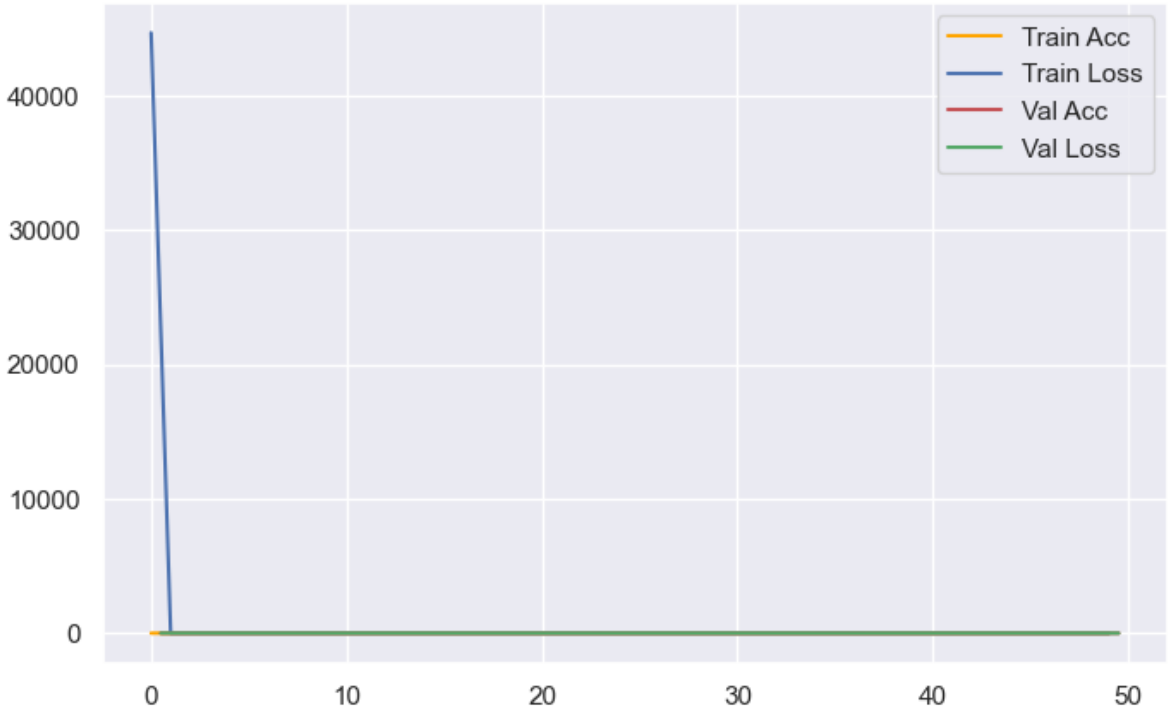
```
# Learning rate
res=[]
for lr in [1,0.1, 0.01,0.001,0.0001]:
    valacc, history, discard = implement(hiddensizes, actfn, opt_ins, lr, n_epochs,
    plot_history(history)
    res += [[lr,valacc]]
```

```
print(res)
```

```
Epoch 1/50
16/16 [==============================] - 1s 7ms/step - loss: 44673.2617 - accurac
y: 0.5112 - val_loss: 2.5765 - val_accuracy: 0.6667
Epoch 2/50
16/16 [==============================] - 0s 2ms/step - loss: 3.9822 - accuracy: 0.
5499 - val_loss: 2.2188 - val_accuracy: 0.6667
Epoch 3/50
16/16 [==============================] - 0s 2ms/step - loss: 3.0800 - accuracy: 0.
5336 - val_loss: 1.0001 - val_accuracy: 0.3333
Epoch 4/50
16/16 [==============================] - 0s 2ms/step - loss: 0.7191 - accuracy: 0.
6253 - val_loss: 0.6466 - val_accuracy: 0.6667
Epoch 5/50
16/16 [==============================] - 0s 2ms/step - loss: 0.8262 - accuracy: 0.
5356 - val_loss: 0.7821 - val_accuracy: 0.6667
Epoch 6/50
16/16 [==============================] - 0s 2ms/step - loss: 1.0060 - accuracy: 0.
5153 - val_loss: 1.3304 - val_accuracy: 0.6667
Epoch 7/50
16/16 [==============================] - 0s 2ms/step - loss: 1.0159 - accuracy: 0.
5397 - val_loss: 0.7520 - val_accuracy: 0.3333
Epoch 8/50
16/16 [==============================] - 0s 2ms/step - loss: 0.7271 - accuracy: 0.
5804 - val_loss: 0.7970 - val_accuracy: 0.3333
Epoch 9/50
16/16 [==============================] - 0s 2ms/step - loss: 0.8999 - accuracy: 0.
5377 - val_loss: 0.7409 - val_accuracy: 0.6667
Epoch 10/50
16/16 [==============================] - 0s 2ms/step - loss: 0.9135 - accuracy: 0.
5499 - val_loss: 1.0950 - val_accuracy: 0.6667
Epoch 11/50
16/16 [==============================] - 0s 2ms/step - loss: 0.8607 - accuracy: 0.
6069 - val_loss: 1.1466 - val_accuracy: 0.3333
Epoch 12/50
16/16 [==============================] - 0s 2ms/step - loss: 0.8221 - accuracy: 0.
5703 - val_loss: 0.8046 - val_accuracy: 0.3333
Epoch 13/50
16/16 [==============================] - 0s 2ms/step - loss: 0.8696 - accuracy: 0.
5438 - val_loss: 1.0303 - val_accuracy: 0.6667
Epoch 14/50
16/16 [==============================] - 0s 2ms/step - loss: 0.9913 - accuracy: 0.
5112 - val_loss: 1.4013 - val_accuracy: 0.6667
Epoch 15/50
16/16 [==============================] - 0s 2ms/step - loss: 0.8128 - accuracy: 0.
5723 - val_loss: 0.6859 - val_accuracy: 0.6667
Epoch 16/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6952 - accuracy: 0.
5886 - val_loss: 0.7179 - val_accuracy: 0.6667
Epoch 17/50
16/16 [==============================] - 0s 2ms/step - loss: 0.7327 - accuracy: 0.
5356 - val_loss: 1.1506 - val_accuracy: 0.6667
Epoch 18/50
16/16 [==============================] - 0s 2ms/step - loss: 1.1642 - accuracy: 0.
5479 - val_loss: 0.9624 - val_accuracy: 0.3333
Epoch 19/50
16/16 [==============================] - 0s 2ms/step - loss: 0.9011 - accuracy: 0.
5275 - val_loss: 0.6409 - val_accuracy: 0.6667
Epoch 20/50
16/16 [==============================] - 0s 2ms/step - loss: 0.7024 - accuracy: 0.
5764 - val_loss: 1.0393 - val_accuracy: 0.3333
Epoch 21/50
16/16 [==============================] - 0s 2ms/step - loss: 0.8313 - accuracy: 0.
5682 - val_loss: 0.7481 - val_accuracy: 0.3333
Epoch 22/50
```

```
16/16 [==============================] - 0s 2ms/step - loss: 0.9950 - accuracy: 0.
5519 - val_loss: 1.4784 - val_accuracy: 0.3333
Epoch 23/50
16/16 [==============================] - 0s 2ms/step - loss: 1.1475 - accuracy: 0.
5356 - val_loss: 0.6566 - val_accuracy: 0.6667
Epoch 24/50
16/16 [==============================] - 0s 2ms/step - loss: 0.7413 - accuracy: 0.
5845 - val_loss: 0.6632 - val_accuracy: 0.6667
Epoch 25/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6909 - accuracy: 0.
5784 - val_loss: 0.7497 - val_accuracy: 0.3333
Epoch 26/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6752 - accuracy: 0.
5967 - val_loss: 0.6860 - val_accuracy: 0.6667
Epoch 27/50
16/16 [==============================] - 0s 2ms/step - loss: 0.7014 - accuracy: 0.
6130 - val_loss: 0.7368 - val_accuracy: 0.3333
Epoch 28/50
16/16 [==============================] - 0s 2ms/step - loss: 0.8189 - accuracy: 0.
5519 - val_loss: 0.9207 - val_accuracy: 0.3333
Epoch 29/50
16/16 [==============================] - 0s 2ms/step - loss: 0.7497 - accuracy: 0.
5397 - val_loss: 0.6460 - val_accuracy: 0.6667
Epoch 30/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6808 - accuracy: 0.
6130 - val_loss: 0.7114 - val_accuracy: 0.3333
Epoch 31/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6747 - accuracy: 0.
5967 - val_loss: 0.6932 - val_accuracy: 0.6667
Epoch 32/50
16/16 [==============================] - 0s 2ms/step - loss: 0.7879 - accuracy: 0.
5479 - val_loss: 0.7017 - val_accuracy: 0.6667
Epoch 33/50
16/16 [==============================] - 0s 2ms/step - loss: 0.7423 - accuracy: 0.
5519 - val_loss: 0.6483 - val_accuracy: 0.6667
Epoch 34/50
16/16 [==============================] - 0s 2ms/step - loss: 0.8289 - accuracy: 0.
5764 - val_loss: 0.6477 - val_accuracy: 0.6667
Epoch 35/50
16/16 [==============================] - 0s 2ms/step - loss: 0.7372 - accuracy: 0.
5621 - val_loss: 0.7940 - val_accuracy: 0.6667
Epoch 36/50
16/16 [==============================] - 0s 2ms/step - loss: 1.0477 - accuracy: 0.
5234 - val_loss: 0.6982 - val_accuracy: 0.6667
Epoch 37/50
16/16 [==============================] - 0s 2ms/step - loss: 0.8684 - accuracy: 0.
5866 - val_loss: 0.7859 - val_accuracy: 0.3333
Epoch 38/50
16/16 [==============================] - 0s 2ms/step - loss: 0.8283 - accuracy: 0.
5234 - val_loss: 0.9422 - val_accuracy: 0.6667
Epoch 39/50
16/16 [==============================] - 0s 2ms/step - loss: 0.8061 - accuracy: 0.
5316 - val_loss: 1.3215 - val_accuracy: 0.3333
Epoch 40/50
16/16 [==============================] - 0s 2ms/step - loss: 0.8495 - accuracy: 0.
5601 - val_loss: 0.8895 - val_accuracy: 0.6667
Epoch 41/50
16/16 [==============================] - 0s 2ms/step - loss: 0.9826 - accuracy: 0.
5662 - val_loss: 0.9290 - val_accuracy: 0.3333
Epoch 42/50
16/16 [==============================] - 0s 2ms/step - loss: 0.8861 - accuracy: 0.
5845 - val_loss: 0.9694 - val_accuracy: 0.6667
Epoch 43/50
16/16 [==============================] - 0s 2ms/step - loss: 1.0680 - accuracy: 0.
```

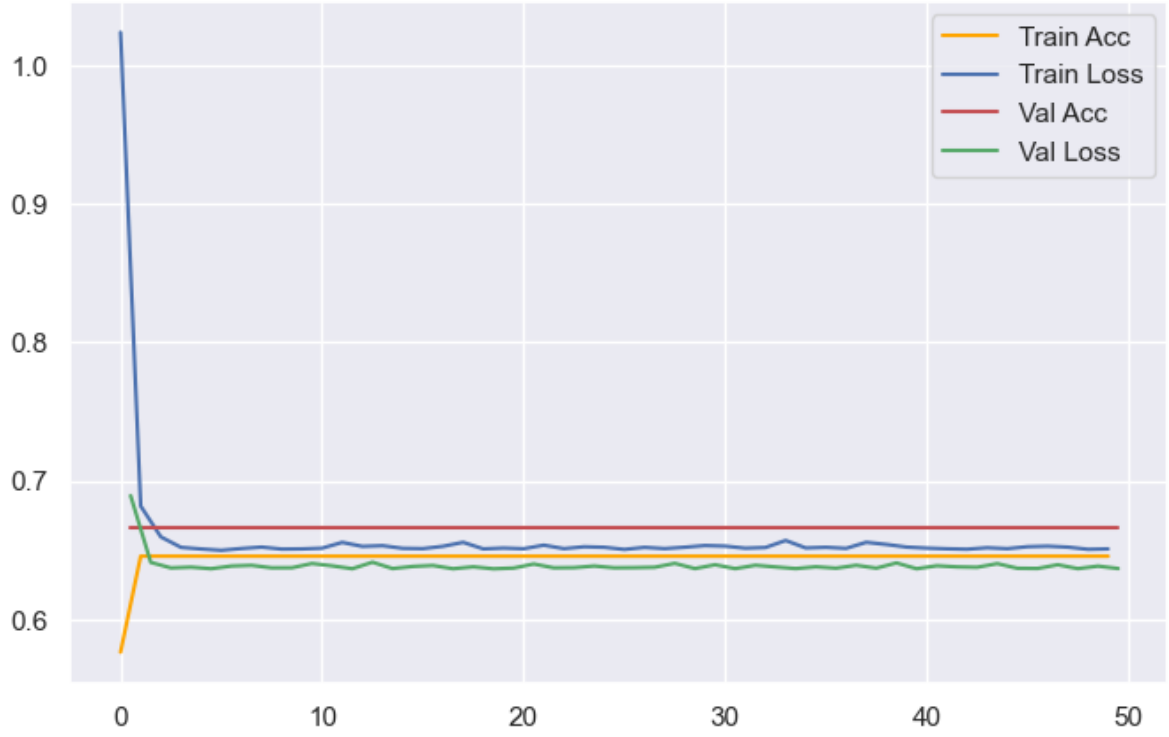
```
6110 - val_loss: 0.8666 - val_accuracy: 0.3333
Epoch 44/50
16/16 [==============================] - 0s 2ms/step - loss: 0.7699 - accuracy: 0.
4949 - val_loss: 0.6412 - val_accuracy: 0.6667
Epoch 45/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6706 - accuracy: 0.
6456 - val_loss: 0.6365 - val_accuracy: 0.6667
Epoch 46/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6579 - accuracy: 0.
6456 - val_loss: 0.6369 - val_accuracy: 0.6667
Epoch 47/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6535 - accuracy: 0.
6456 - val_loss: 0.6374 - val_accuracy: 0.6667
Epoch 48/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6528 - accuracy: 0.
6456 - val_loss: 0.6451 - val_accuracy: 0.6667
Epoch 49/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6657 - accuracy: 0.
6456 - val_loss: 0.6454 - val_accuracy: 0.6667
Epoch 50/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6696 - accuracy: 0.
5764 - val_loss: 0.6619 - val_accuracy: 0.6667
```



```
Epoch 1/50
16/16 [==============================] - 1s 7ms/step - loss: 1.0237 - accuracy: 0.
5764 - val_loss: 0.6893 - val_accuracy: 0.6667
Epoch 2/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6818 - accuracy: 0.
6456 - val_loss: 0.6411 - val_accuracy: 0.6667
Epoch 3/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6596 - accuracy: 0.
6456 - val_loss: 0.6372 - val_accuracy: 0.6667
Epoch 4/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6520 - accuracy: 0.
6456 - val_loss: 0.6377 - val_accuracy: 0.6667
Epoch 5/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6508 - accuracy: 0.
6456 - val_loss: 0.6366 - val_accuracy: 0.6667
Epoch 6/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6499 - accuracy: 0.
6456 - val_loss: 0.6385 - val_accuracy: 0.6667
Epoch 7/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6512 - accuracy: 0.
6456 - val_loss: 0.6390 - val_accuracy: 0.6667
Epoch 8/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6522 - accuracy: 0.
6456 - val_loss: 0.6372 - val_accuracy: 0.6667
Epoch 9/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6507 - accuracy: 0.
6456 - val_loss: 0.6373 - val_accuracy: 0.6667
Epoch 10/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6509 - accuracy: 0.
6456 - val_loss: 0.6403 - val_accuracy: 0.6667
Epoch 11/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6514 - accuracy: 0.
6456 - val_loss: 0.6387 - val_accuracy: 0.6667
Epoch 12/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6556 - accuracy: 0.
6456 - val_loss: 0.6366 - val_accuracy: 0.6667
Epoch 13/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6527 - accuracy: 0.
6456 - val_loss: 0.6413 - val_accuracy: 0.6667
Epoch 14/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6532 - accuracy: 0.
6456 - val_loss: 0.6367 - val_accuracy: 0.6667
Epoch 15/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6513 - accuracy: 0.
6456 - val_loss: 0.6382 - val_accuracy: 0.6667
Epoch 16/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6511 - accuracy: 0.
6456 - val_loss: 0.6389 - val_accuracy: 0.6667
Epoch 17/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6528 - accuracy: 0.
6456 - val_loss: 0.6366 - val_accuracy: 0.6667
Epoch 18/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6556 - accuracy: 0.
6456 - val_loss: 0.6380 - val_accuracy: 0.6667
Epoch 19/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6509 - accuracy: 0.
6456 - val_loss: 0.6365 - val_accuracy: 0.6667
Epoch 20/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6515 - accuracy: 0.
6456 - val_loss: 0.6371 - val_accuracy: 0.6667
Epoch 21/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6510 - accuracy: 0.
6456 - val_loss: 0.6400 - val_accuracy: 0.6667
Epoch 22/50
```

```
16/16 [==============================] - 0s 2ms/step - loss: 0.6536 - accuracy: 0.
6456 - val_loss: 0.6372 - val_accuracy: 0.6667
Epoch 23/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6511 - accuracy: 0.
6456 - val_loss: 0.6374 - val_accuracy: 0.6667
Epoch 24/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6524 - accuracy: 0.
6456 - val_loss: 0.6385 - val_accuracy: 0.6667
Epoch 25/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6520 - accuracy: 0.
6456 - val_loss: 0.6372 - val_accuracy: 0.6667
Epoch 26/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6505 - accuracy: 0.
6456 - val_loss: 0.6373 - val_accuracy: 0.6667
Epoch 27/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6520 - accuracy: 0.
6456 - val_loss: 0.6376 - val_accuracy: 0.6667
Epoch 28/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6511 - accuracy: 0.
6456 - val_loss: 0.6404 - val_accuracy: 0.6667
Epoch 29/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6521 - accuracy: 0.
6456 - val_loss: 0.6367 - val_accuracy: 0.6667
Epoch 30/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6533 - accuracy: 0.
6456 - val_loss: 0.6394 - val_accuracy: 0.6667
Epoch 31/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6529 - accuracy: 0.
6456 - val_loss: 0.6366 - val_accuracy: 0.6667
Epoch 32/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6514 - accuracy: 0.
6456 - val_loss: 0.6391 - val_accuracy: 0.6667
Epoch 33/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6519 - accuracy: 0.
6456 - val_loss: 0.6379 - val_accuracy: 0.6667
Epoch 34/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6570 - accuracy: 0.
6456 - val_loss: 0.6367 - val_accuracy: 0.6667
Epoch 35/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6516 - accuracy: 0.
6456 - val_loss: 0.6380 - val_accuracy: 0.6667
Epoch 36/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6520 - accuracy: 0.
6456 - val_loss: 0.6370 - val_accuracy: 0.6667
Epoch 37/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6513 - accuracy: 0.
6456 - val_loss: 0.6391 - val_accuracy: 0.6667
Epoch 38/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6556 - accuracy: 0.
6456 - val_loss: 0.6370 - val_accuracy: 0.6667
Epoch 39/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6541 - accuracy: 0.
6456 - val_loss: 0.6408 - val_accuracy: 0.6667
Epoch 40/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6522 - accuracy: 0.
6456 - val_loss: 0.6366 - val_accuracy: 0.6667
Epoch 41/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6515 - accuracy: 0.
6456 - val_loss: 0.6387 - val_accuracy: 0.6667
Epoch 42/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6510 - accuracy: 0.
6456 - val_loss: 0.6379 - val_accuracy: 0.6667
Epoch 43/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6506 - accuracy: 0.
```

```
6456 - val_loss: 0.6376 - val_accuracy: 0.6667
Epoch 44/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6517 - accuracy: 0.
6456 - val_loss: 0.6403 - val_accuracy: 0.6667
Epoch 45/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6511 - accuracy: 0.
6456 - val_loss: 0.6369 - val_accuracy: 0.6667
Epoch 46/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6525 - accuracy: 0.
6456 - val_loss: 0.6367 - val_accuracy: 0.6667
Epoch 47/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6528 - accuracy: 0.
6456 - val_loss: 0.6395 - val_accuracy: 0.6667
Epoch 48/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6522 - accuracy: 0.
6456 - val_loss: 0.6366 - val_accuracy: 0.6667
Epoch 49/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6506 - accuracy: 0.
6456 - val_loss: 0.6385 - val_accuracy: 0.6667
Epoch 50/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6509 - accuracy: 0.
6456 - val_loss: 0.6367 - val_accuracy: 0.6667
```



```
Epoch 1/50
16/16 [==============================] - 1s 8ms/step - loss: 0.6394 - accuracy: 0.
6253 - val_loss: 0.5251 - val_accuracy: 0.7642
Epoch 2/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5635 - accuracy: 0.
6986 - val_loss: 0.4731 - val_accuracy: 0.7967
Epoch 3/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5484 - accuracy: 0.
7006 - val_loss: 0.4717 - val_accuracy: 0.7886
Epoch 4/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5127 - accuracy: 0.
7536 - val_loss: 0.4578 - val_accuracy: 0.7886
Epoch 5/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5098 - accuracy: 0.
7413 - val_loss: 0.4870 - val_accuracy: 0.7805
Epoch 6/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5003 - accuracy: 0.
7536 - val_loss: 0.4822 - val_accuracy: 0.7967
Epoch 7/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4951 - accuracy: 0.
7556 - val_loss: 0.4353 - val_accuracy: 0.8049
Epoch 8/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4688 - accuracy: 0.
7658 - val_loss: 0.4483 - val_accuracy: 0.7724
Epoch 9/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4552 - accuracy: 0.
7576 - val_loss: 0.4587 - val_accuracy: 0.7805
Epoch 10/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4635 - accuracy: 0.
7699 - val_loss: 0.4617 - val_accuracy: 0.7642
Epoch 11/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4543 - accuracy: 0.
7821 - val_loss: 0.4760 - val_accuracy: 0.7642
Epoch 12/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4422 - accuracy: 0.
7760 - val_loss: 0.5234 - val_accuracy: 0.7805
Epoch 13/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4498 - accuracy: 0.
7841 - val_loss: 0.4799 - val_accuracy: 0.7480
Epoch 14/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4492 - accuracy: 0.
7637 - val_loss: 0.4768 - val_accuracy: 0.7724
Epoch 15/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4367 - accuracy: 0.
7862 - val_loss: 0.4797 - val_accuracy: 0.7805
Epoch 16/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4313 - accuracy: 0.
7902 - val_loss: 0.4753 - val_accuracy: 0.7642
Epoch 17/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4262 - accuracy: 0.
7943 - val_loss: 0.5224 - val_accuracy: 0.7805
Epoch 18/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4718 - accuracy: 0.
7556 - val_loss: 0.4890 - val_accuracy: 0.7642
Epoch 19/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4627 - accuracy: 0.
7719 - val_loss: 0.5030 - val_accuracy: 0.7805
Epoch 20/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4543 - accuracy: 0.
7658 - val_loss: 0.5284 - val_accuracy: 0.7642
Epoch 21/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4316 - accuracy: 0.
8045 - val_loss: 0.4949 - val_accuracy: 0.7642
Epoch 22/50
```

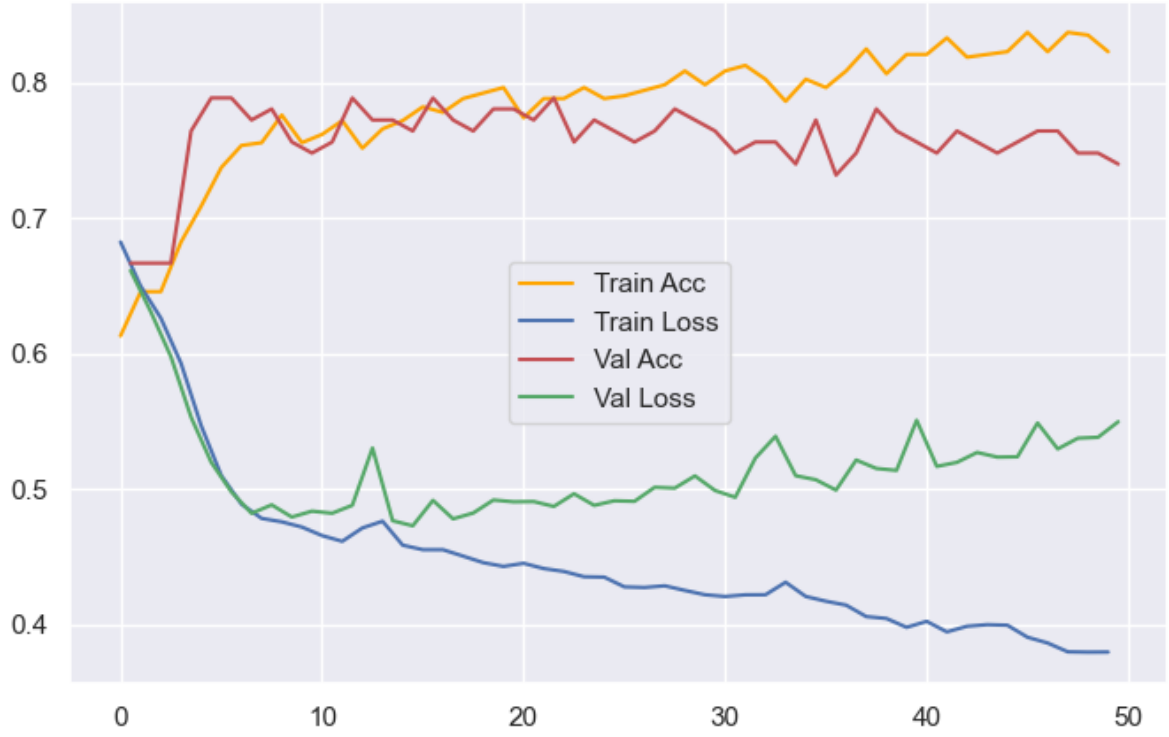
```
16/16 [==============================] - 0s 2ms/step - loss: 0.4465 - accuracy: 0.
7943 - val_loss: 0.5605 - val_accuracy: 0.7398
Epoch 23/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4473 - accuracy: 0.
7739 - val_loss: 0.4989 - val_accuracy: 0.7561
Epoch 24/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4599 - accuracy: 0.
7943 - val_loss: 0.5375 - val_accuracy: 0.7480
Epoch 25/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4266 - accuracy: 0.
7943 - val_loss: 0.5222 - val_accuracy: 0.7642
Epoch 26/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4099 - accuracy: 0.
8106 - val_loss: 0.5320 - val_accuracy: 0.7642
Epoch 27/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4055 - accuracy: 0.
7984 - val_loss: 0.5962 - val_accuracy: 0.7642
Epoch 28/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4144 - accuracy: 0.
8126 - val_loss: 0.5053 - val_accuracy: 0.7642
Epoch 29/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4151 - accuracy: 0.
8065 - val_loss: 0.5722 - val_accuracy: 0.7642
Epoch 30/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4183 - accuracy: 0.
8045 - val_loss: 0.5359 - val_accuracy: 0.7642
Epoch 31/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4058 - accuracy: 0.
8086 - val_loss: 0.6036 - val_accuracy: 0.7561
Epoch 32/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4104 - accuracy: 0.
7963 - val_loss: 0.5578 - val_accuracy: 0.7561
Epoch 33/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4012 - accuracy: 0.
8045 - val_loss: 0.5653 - val_accuracy: 0.7642
Epoch 34/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4240 - accuracy: 0.
7760 - val_loss: 0.5216 - val_accuracy: 0.7642
Epoch 35/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4044 - accuracy: 0.
8065 - val_loss: 0.5963 - val_accuracy: 0.7561
Epoch 36/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4081 - accuracy: 0.
7963 - val_loss: 0.5281 - val_accuracy: 0.7642
Epoch 37/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4205 - accuracy: 0.
8024 - val_loss: 0.5389 - val_accuracy: 0.7480
Epoch 38/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4047 - accuracy: 0.
8045 - val_loss: 0.5677 - val_accuracy: 0.7480
Epoch 39/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4112 - accuracy: 0.
8024 - val_loss: 0.5476 - val_accuracy: 0.7642
Epoch 40/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4052 - accuracy: 0.
7984 - val_loss: 0.5755 - val_accuracy: 0.7886
Epoch 41/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4210 - accuracy: 0.
7963 - val_loss: 0.5878 - val_accuracy: 0.7561
Epoch 42/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4491 - accuracy: 0.
8024 - val_loss: 0.5168 - val_accuracy: 0.7561
Epoch 43/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4433 - accuracy: 0.
```

```
7862 - val_loss: 0.5702 - val_accuracy: 0.7642
Epoch 44/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4097 - accuracy: 0.
8024 - val_loss: 0.5502 - val_accuracy: 0.7805
Epoch 45/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3879 - accuracy: 0.
8045 - val_loss: 0.6644 - val_accuracy: 0.7642
Epoch 46/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3792 - accuracy: 0.
8228 - val_loss: 0.5649 - val_accuracy: 0.7805
Epoch 47/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3866 - accuracy: 0.
8004 - val_loss: 0.6646 - val_accuracy: 0.7805
Epoch 48/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3751 - accuracy: 0.
8065 - val_loss: 0.6031 - val_accuracy: 0.7642
Epoch 49/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3773 - accuracy: 0.
8126 - val_loss: 0.6134 - val_accuracy: 0.7642
Epoch 50/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3823 - accuracy: 0.
8024 - val_loss: 0.6511 - val_accuracy: 0.7480
```

```
Epoch 1/50
16/16 [==============================] - 1s 7ms/step - loss: 0.6823 - accuracy: 0.
6130 - val_loss: 0.6611 - val_accuracy: 0.6667
Epoch 2/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6496 - accuracy: 0.
6456 - val_loss: 0.6308 - val_accuracy: 0.6667
Epoch 3/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6261 - accuracy: 0.
6456 - val_loss: 0.5976 - val_accuracy: 0.6667
Epoch 4/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5928 - accuracy: 0.
6823 - val_loss: 0.5529 - val_accuracy: 0.7642
Epoch 5/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5467 - accuracy: 0.
7088 - val_loss: 0.5196 - val_accuracy: 0.7886
Epoch 6/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5098 - accuracy: 0.
7373 - val_loss: 0.4978 - val_accuracy: 0.7886
Epoch 7/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4888 - accuracy: 0.
7536 - val_loss: 0.4819 - val_accuracy: 0.7724
Epoch 8/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4782 - accuracy: 0.
7556 - val_loss: 0.4882 - val_accuracy: 0.7805
Epoch 9/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4757 - accuracy: 0.
7760 - val_loss: 0.4792 - val_accuracy: 0.7561
Epoch 10/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4718 - accuracy: 0.
7556 - val_loss: 0.4836 - val_accuracy: 0.7480
Epoch 11/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4655 - accuracy: 0.
7617 - val_loss: 0.4820 - val_accuracy: 0.7561
Epoch 12/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4613 - accuracy: 0.
7719 - val_loss: 0.4879 - val_accuracy: 0.7886
Epoch 13/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4711 - accuracy: 0.
7515 - val_loss: 0.5301 - val_accuracy: 0.7724
Epoch 14/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4761 - accuracy: 0.
7658 - val_loss: 0.4765 - val_accuracy: 0.7724
Epoch 15/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4584 - accuracy: 0.
7719 - val_loss: 0.4727 - val_accuracy: 0.7642
Epoch 16/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4551 - accuracy: 0.
7821 - val_loss: 0.4915 - val_accuracy: 0.7886
Epoch 17/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4551 - accuracy: 0.
7780 - val_loss: 0.4779 - val_accuracy: 0.7724
Epoch 18/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4503 - accuracy: 0.
7882 - val_loss: 0.4822 - val_accuracy: 0.7642
Epoch 19/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4455 - accuracy: 0.
7923 - val_loss: 0.4918 - val_accuracy: 0.7805
Epoch 20/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4428 - accuracy: 0.
7963 - val_loss: 0.4904 - val_accuracy: 0.7805
Epoch 21/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4451 - accuracy: 0.
7739 - val_loss: 0.4906 - val_accuracy: 0.7724
Epoch 22/50
```

```
16/16 [==============================] - 0s 2ms/step - loss: 0.4412 - accuracy: 0.
7882 - val_loss: 0.4871 - val_accuracy: 0.7886
Epoch 23/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4390 - accuracy: 0.
7882 - val_loss: 0.4964 - val_accuracy: 0.7561
Epoch 24/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4351 - accuracy: 0.
7963 - val_loss: 0.4878 - val_accuracy: 0.7724
Epoch 25/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4348 - accuracy: 0.
7882 - val_loss: 0.4912 - val_accuracy: 0.7642
Epoch 26/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4276 - accuracy: 0.
7902 - val_loss: 0.4908 - val_accuracy: 0.7561
Epoch 27/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4272 - accuracy: 0.
7943 - val_loss: 0.5012 - val_accuracy: 0.7642
Epoch 28/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4284 - accuracy: 0.
7984 - val_loss: 0.5006 - val_accuracy: 0.7805
Epoch 29/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4250 - accuracy: 0.
8086 - val_loss: 0.5096 - val_accuracy: 0.7724
Epoch 30/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4218 - accuracy: 0.
7984 - val_loss: 0.4988 - val_accuracy: 0.7642
Epoch 31/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4206 - accuracy: 0.
8086 - val_loss: 0.4938 - val_accuracy: 0.7480
Epoch 32/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4218 - accuracy: 0.
8126 - val_loss: 0.5228 - val_accuracy: 0.7561
Epoch 33/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4218 - accuracy: 0.
8024 - val_loss: 0.5388 - val_accuracy: 0.7561
Epoch 34/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4311 - accuracy: 0.
7862 - val_loss: 0.5097 - val_accuracy: 0.7398
Epoch 35/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4206 - accuracy: 0.
8024 - val_loss: 0.5067 - val_accuracy: 0.7724
Epoch 36/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4171 - accuracy: 0.
7963 - val_loss: 0.4991 - val_accuracy: 0.7317
Epoch 37/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4142 - accuracy: 0.
8086 - val_loss: 0.5213 - val_accuracy: 0.7480
Epoch 38/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4057 - accuracy: 0.
8248 - val_loss: 0.5151 - val_accuracy: 0.7805
Epoch 39/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4043 - accuracy: 0.
8065 - val_loss: 0.5136 - val_accuracy: 0.7642
Epoch 40/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3978 - accuracy: 0.
8208 - val_loss: 0.5507 - val_accuracy: 0.7561
Epoch 41/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4022 - accuracy: 0.
8208 - val_loss: 0.5166 - val_accuracy: 0.7480
Epoch 42/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3944 - accuracy: 0.
8330 - val_loss: 0.5196 - val_accuracy: 0.7642
Epoch 43/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3986 - accuracy: 0.
```

```
8187 - val_loss: 0.5269 - val_accuracy: 0.7561
Epoch 44/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3998 - accuracy: 0.
8208 - val_loss: 0.5235 - val_accuracy: 0.7480
Epoch 45/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3994 - accuracy: 0.
8228 - val_loss: 0.5237 - val_accuracy: 0.7561
Epoch 46/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3905 - accuracy: 0.
8371 - val_loss: 0.5487 - val_accuracy: 0.7642
Epoch 47/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3862 - accuracy: 0.
8228 - val_loss: 0.5295 - val_accuracy: 0.7642
Epoch 48/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3797 - accuracy: 0.
8371 - val_loss: 0.5374 - val_accuracy: 0.7480
Epoch 49/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3795 - accuracy: 0.
8350 - val_loss: 0.5381 - val_accuracy: 0.7480
Epoch 50/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3795 - accuracy: 0.
8228 - val_loss: 0.5496 - val_accuracy: 0.7398
```



```
Epoch 1/50
16/16 [==============================] - 1s 7ms/step - loss: 0.6984 - accuracy: 0.
3666 - val_loss: 0.6941 - val_accuracy: 0.3740
Epoch 2/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6909 - accuracy: 0.
5866 - val_loss: 0.6862 - val_accuracy: 0.6667
Epoch 3/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6841 - accuracy: 0.
6456 - val_loss: 0.6790 - val_accuracy: 0.6667
Epoch 4/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6777 - accuracy: 0.
6456 - val_loss: 0.6718 - val_accuracy: 0.6667
Epoch 5/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6713 - accuracy: 0.
6456 - val_loss: 0.6639 - val_accuracy: 0.6667
Epoch 6/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6647 - accuracy: 0.
6456 - val_loss: 0.6569 - val_accuracy: 0.6667
Epoch 7/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6583 - accuracy: 0.
6456 - val_loss: 0.6490 - val_accuracy: 0.6667
Epoch 8/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6513 - accuracy: 0.
6456 - val_loss: 0.6402 - val_accuracy: 0.6667
Epoch 9/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6441 - accuracy: 0.
6456 - val_loss: 0.6323 - val_accuracy: 0.6667
Epoch 10/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6376 - accuracy: 0.
6456 - val_loss: 0.6234 - val_accuracy: 0.6667
Epoch 11/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6303 - accuracy: 0.
6456 - val_loss: 0.6153 - val_accuracy: 0.6667
Epoch 12/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6244 - accuracy: 0.
6456 - val_loss: 0.6073 - val_accuracy: 0.6667
Epoch 13/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6183 - accuracy: 0.
6456 - val_loss: 0.6000 - val_accuracy: 0.6667
Epoch 14/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6126 - accuracy: 0.
6456 - val_loss: 0.5932 - val_accuracy: 0.6667
Epoch 15/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6081 - accuracy: 0.
6456 - val_loss: 0.5859 - val_accuracy: 0.6667
Epoch 16/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6029 - accuracy: 0.
6456 - val_loss: 0.5799 - val_accuracy: 0.6667
Epoch 17/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5988 - accuracy: 0.
6456 - val_loss: 0.5737 - val_accuracy: 0.6667
Epoch 18/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5946 - accuracy: 0.
6456 - val_loss: 0.5675 - val_accuracy: 0.6667
Epoch 19/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5904 - accuracy: 0.
6456 - val_loss: 0.5614 - val_accuracy: 0.6667
Epoch 20/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5863 - accuracy: 0.
6456 - val_loss: 0.5555 - val_accuracy: 0.6667
Epoch 21/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5821 - accuracy: 0.
6477 - val_loss: 0.5505 - val_accuracy: 0.6667
Epoch 22/50
```

```
16/16 [==============================] - 0s 2ms/step - loss: 0.5780 - accuracy: 0.
6538 - val_loss: 0.5450 - val_accuracy: 0.6667
Epoch 23/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5741 - accuracy: 0.
6619 - val_loss: 0.5396 - val_accuracy: 0.6829
Epoch 24/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5707 - accuracy: 0.
6721 - val_loss: 0.5338 - val_accuracy: 0.6992
Epoch 25/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5663 - accuracy: 0.
6843 - val_loss: 0.5284 - val_accuracy: 0.7073
Epoch 26/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5621 - accuracy: 0.
6965 - val_loss: 0.5243 - val_accuracy: 0.7073
Epoch 27/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5585 - accuracy: 0.
7047 - val_loss: 0.5192 - val_accuracy: 0.7154
Epoch 28/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5549 - accuracy: 0.
7088 - val_loss: 0.5145 - val_accuracy: 0.6992
Epoch 29/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5513 - accuracy: 0.
7210 - val_loss: 0.5107 - val_accuracy: 0.7154
Epoch 30/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5482 - accuracy: 0.
7210 - val_loss: 0.5054 - val_accuracy: 0.7317
Epoch 31/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5446 - accuracy: 0.
7210 - val_loss: 0.5015 - val_accuracy: 0.7642
Epoch 32/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5419 - accuracy: 0.
7189 - val_loss: 0.4977 - val_accuracy: 0.7805
Epoch 33/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5388 - accuracy: 0.
7210 - val_loss: 0.4941 - val_accuracy: 0.7805
Epoch 34/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5361 - accuracy: 0.
7169 - val_loss: 0.4906 - val_accuracy: 0.7886
Epoch 35/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5337 - accuracy: 0.
7251 - val_loss: 0.4871 - val_accuracy: 0.7886
Epoch 36/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5314 - accuracy: 0.
7169 - val_loss: 0.4859 - val_accuracy: 0.8049
Epoch 37/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5286 - accuracy: 0.
7088 - val_loss: 0.4832 - val_accuracy: 0.8130
Epoch 38/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5265 - accuracy: 0.
7149 - val_loss: 0.4807 - val_accuracy: 0.8130
Epoch 39/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5240 - accuracy: 0.
7149 - val_loss: 0.4786 - val_accuracy: 0.8130
Epoch 40/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5224 - accuracy: 0.
7149 - val_loss: 0.4769 - val_accuracy: 0.8130
Epoch 41/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5206 - accuracy: 0.
7128 - val_loss: 0.4758 - val_accuracy: 0.8211
Epoch 42/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5189 - accuracy: 0.
7251 - val_loss: 0.4753 - val_accuracy: 0.8211
Epoch 43/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5168 - accuracy: 0.
```

```
7271 - val_loss: 0.4734 - val_accuracy: 0.8211
Epoch 44/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5160 - accuracy: 0.
7230 - val_loss: 0.4723 - val_accuracy: 0.8211
Epoch 45/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5131 - accuracy: 0.
7352 - val_loss: 0.4719 - val_accuracy: 0.8130
Epoch 46/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5128 - accuracy: 0.
7312 - val_loss: 0.4720 - val_accuracy: 0.8049
Epoch 47/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5105 - accuracy: 0.
7312 - val_loss: 0.4696 - val_accuracy: 0.8211
Epoch 48/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5095 - accuracy: 0.
7312 - val_loss: 0.4690 - val_accuracy: 0.8211
Epoch 49/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5077 - accuracy: 0.
7352 - val_loss: 0.4695 - val_accuracy: 0.8130
Epoch 50/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5061 - accuracy: 0.
7352 - val_loss: 0.4675 - val_accuracy: 0.8130
```


```
[[1, 0.6666666865348816], [0.1, 0.6666666865348816], [0.01, 0.8048780560493469],
[0.001, 0.7886179089546204], [0.0001, 0.8211382031440735]]
```

In [8]:

```
res=[]
optimizer_setup = [[keras.optimizers.SGD,0.001], [keras.optimizers.Adam,0.001],[ker
for optimizer,lr in optimizer_setup :
    valacc, history, discard = implement(hiddensizes, actfn, optimizer, lr, n_epoch
    plot_history(history)
    res += [[valacc]]
print(res)
```

```
Epoch 1/50
16/16 [==============================] - 1s 17ms/step - loss: 0.6926 - accuracy:
0.5764 - val_loss: 0.6923 - val_accuracy: 0.5935
Epoch 2/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6919 - accuracy: 0.
5967 - val_loss: 0.6914 - val_accuracy: 0.6341
Epoch 3/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6911 - accuracy: 0.
6517 - val_loss: 0.6906 - val_accuracy: 0.6585
Epoch 4/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6903 - accuracy: 0.
6538 - val_loss: 0.6897 - val_accuracy: 0.6585
Epoch 5/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6896 - accuracy: 0.
6456 - val_loss: 0.6888 - val_accuracy: 0.6667
Epoch 6/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6888 - accuracy: 0.
6456 - val_loss: 0.6880 - val_accuracy: 0.6667
Epoch 7/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6881 - accuracy: 0.
6477 - val_loss: 0.6872 - val_accuracy: 0.6667
Epoch 8/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6874 - accuracy: 0.
6477 - val_loss: 0.6865 - val_accuracy: 0.6667
Epoch 9/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6867 - accuracy: 0.
6456 - val_loss: 0.6857 - val_accuracy: 0.6667
Epoch 10/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6861 - accuracy: 0.
6477 - val_loss: 0.6849 - val_accuracy: 0.6667
Epoch 11/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6854 - accuracy: 0.
6477 - val_loss: 0.6841 - val_accuracy: 0.6667
Epoch 12/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6847 - accuracy: 0.
6477 - val_loss: 0.6834 - val_accuracy: 0.6667
Epoch 13/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6841 - accuracy: 0.
6456 - val_loss: 0.6827 - val_accuracy: 0.6667
Epoch 14/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6835 - accuracy: 0.
6456 - val_loss: 0.6820 - val_accuracy: 0.6667
Epoch 15/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6828 - accuracy: 0.
6456 - val_loss: 0.6812 - val_accuracy: 0.6667
Epoch 16/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6822 - accuracy: 0.
6456 - val_loss: 0.6805 - val_accuracy: 0.6667
Epoch 17/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6816 - accuracy: 0.
6456 - val_loss: 0.6798 - val_accuracy: 0.6667
Epoch 18/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6810 - accuracy: 0.
6456 - val_loss: 0.6792 - val_accuracy: 0.6667
Epoch 19/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6805 - accuracy: 0.
6456 - val_loss: 0.6786 - val_accuracy: 0.6667
Epoch 20/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6799 - accuracy: 0.
6456 - val_loss: 0.6779 - val_accuracy: 0.6667
Epoch 21/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6794 - accuracy: 0.
6456 - val_loss: 0.6773 - val_accuracy: 0.6667
Epoch 22/50
```

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16/16 [==============================] - 0s 2ms/step - loss: 0.6789 - accuracy: 0.
6456 - val_loss: 0.6767 - val_accuracy: 0.6667
Epoch 23/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6783 - accuracy: 0.
6456 - val_loss: 0.6761 - val_accuracy: 0.6667
Epoch 24/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6778 - accuracy: 0.
6456 - val_loss: 0.6754 - val_accuracy: 0.6667
Epoch 25/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6773 - accuracy: 0.
6456 - val_loss: 0.6749 - val_accuracy: 0.6667
Epoch 26/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6768 - accuracy: 0.
6456 - val_loss: 0.6743 - val_accuracy: 0.6667
Epoch 27/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6763 - accuracy: 0.
6456 - val_loss: 0.6737 - val_accuracy: 0.6667
Epoch 28/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6758 - accuracy: 0.
6456 - val_loss: 0.6731 - val_accuracy: 0.6667
Epoch 29/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6753 - accuracy: 0.
6456 - val_loss: 0.6726 - val_accuracy: 0.6667
Epoch 30/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6748 - accuracy: 0.
6456 - val_loss: 0.6721 - val_accuracy: 0.6667
Epoch 31/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6744 - accuracy: 0.
6456 - val_loss: 0.6716 - val_accuracy: 0.6667
Epoch 32/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6740 - accuracy: 0.
6456 - val_loss: 0.6710 - val_accuracy: 0.6667
Epoch 33/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6735 - accuracy: 0.
6456 - val_loss: 0.6705 - val_accuracy: 0.6667
Epoch 34/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6731 - accuracy: 0.
6456 - val_loss: 0.6700 - val_accuracy: 0.6667
Epoch 35/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6727 - accuracy: 0.
6456 - val_loss: 0.6695 - val_accuracy: 0.6667
Epoch 36/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6723 - accuracy: 0.
6456 - val_loss: 0.6691 - val_accuracy: 0.6667
Epoch 37/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6719 - accuracy: 0.
6456 - val_loss: 0.6686 - val_accuracy: 0.6667
Epoch 38/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6715 - accuracy: 0.
6456 - val_loss: 0.6681 - val_accuracy: 0.6667
Epoch 39/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6711 - accuracy: 0.
6456 - val_loss: 0.6677 - val_accuracy: 0.6667
Epoch 40/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6707 - accuracy: 0.
6456 - val_loss: 0.6672 - val_accuracy: 0.6667
Epoch 41/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6704 - accuracy: 0.
6456 - val_loss: 0.6668 - val_accuracy: 0.6667
Epoch 42/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6700 - accuracy: 0.
6456 - val_loss: 0.6663 - val_accuracy: 0.6667
Epoch 43/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6696 - accuracy: 0.
```

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6456 - val_loss: 0.6659 - val_accuracy: 0.6667
Epoch 44/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6692 - accuracy: 0.
6456 - val_loss: 0.6655 - val_accuracy: 0.6667
Epoch 45/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6689 - accuracy: 0.
6456 - val_loss: 0.6651 - val_accuracy: 0.6667
Epoch 46/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6686 - accuracy: 0.
6456 - val_loss: 0.6647 - val_accuracy: 0.6667
Epoch 47/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6682 - accuracy: 0.
6456 - val_loss: 0.6643 - val_accuracy: 0.6667
Epoch 48/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6679 - accuracy: 0.
6456 - val_loss: 0.6639 - val_accuracy: 0.6667
Epoch 49/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6676 - accuracy: 0.
6456 - val_loss: 0.6635 - val_accuracy: 0.6667
Epoch 50/50
16/16 [==============================] - 0s 2ms/step - loss: 0.6673 - accuracy: 0.
6456 - val_loss: 0.6631 - val_accuracy: 0.6667
```

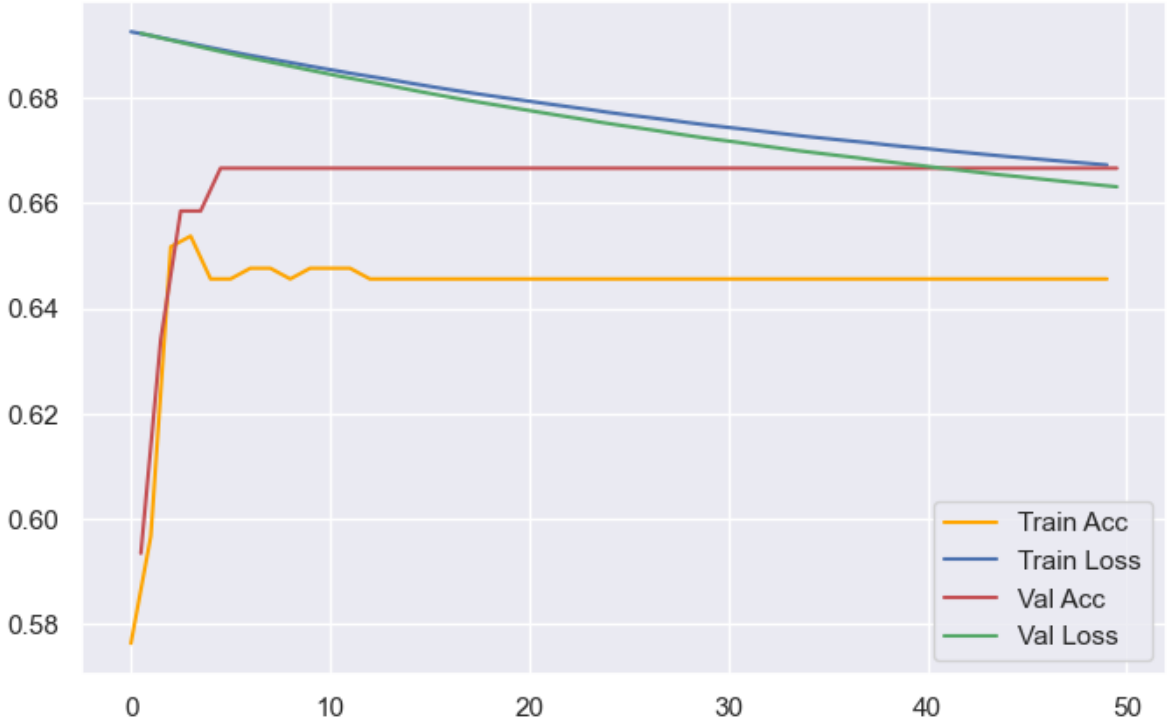

```
Epoch 1/50
16/16 [==============================] - 1s 7ms/step - loss: 0.6493 - accuracy: 0.
6456 - val_loss: 0.5977 - val_accuracy: 0.6667
Epoch 2/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5951 - accuracy: 0.
6456 - val_loss: 0.5666 - val_accuracy: 0.6667
Epoch 3/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5750 - accuracy: 0.
6640 - val_loss: 0.5477 - val_accuracy: 0.7398
Epoch 4/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5508 - accuracy: 0.
7210 - val_loss: 0.5310 - val_accuracy: 0.7561
Epoch 5/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5311 - accuracy: 0.
7352 - val_loss: 0.5228 - val_accuracy: 0.7642
Epoch 6/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5153 - accuracy: 0.
7495 - val_loss: 0.5202 - val_accuracy: 0.7642
Epoch 7/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5027 - accuracy: 0.
7556 - val_loss: 0.5135 - val_accuracy: 0.7642
Epoch 8/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4921 - accuracy: 0.
7556 - val_loss: 0.5106 - val_accuracy: 0.7561
Epoch 9/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4861 - accuracy: 0.
7576 - val_loss: 0.5071 - val_accuracy: 0.7724
Epoch 10/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4758 - accuracy: 0.
7780 - val_loss: 0.5060 - val_accuracy: 0.7724
Epoch 11/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4688 - accuracy: 0.
7739 - val_loss: 0.5047 - val_accuracy: 0.7886
Epoch 12/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4713 - accuracy: 0.
7739 - val_loss: 0.5093 - val_accuracy: 0.7724
Epoch 13/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4706 - accuracy: 0.
7739 - val_loss: 0.4974 - val_accuracy: 0.7724
Epoch 14/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4637 - accuracy: 0.
7821 - val_loss: 0.5002 - val_accuracy: 0.7724
Epoch 15/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4587 - accuracy: 0.
7841 - val_loss: 0.5036 - val_accuracy: 0.7886
Epoch 16/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4603 - accuracy: 0.
7821 - val_loss: 0.5050 - val_accuracy: 0.7724
Epoch 17/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4582 - accuracy: 0.
7862 - val_loss: 0.5039 - val_accuracy: 0.7805
Epoch 18/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4573 - accuracy: 0.
7841 - val_loss: 0.5109 - val_accuracy: 0.7886
Epoch 19/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4565 - accuracy: 0.
7739 - val_loss: 0.5087 - val_accuracy: 0.7805
Epoch 20/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4575 - accuracy: 0.
7841 - val_loss: 0.5058 - val_accuracy: 0.7886
Epoch 21/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4482 - accuracy: 0.
7882 - val_loss: 0.4947 - val_accuracy: 0.7886
Epoch 22/50
```

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16/16 [==============================] - 0s 2ms/step - loss: 0.4459 - accuracy: 0.
7882 - val_loss: 0.5003 - val_accuracy: 0.7805
Epoch 23/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4432 - accuracy: 0.
7923 - val_loss: 0.5001 - val_accuracy: 0.7886
Epoch 24/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4407 - accuracy: 0.
7963 - val_loss: 0.5007 - val_accuracy: 0.7805
Epoch 25/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4432 - accuracy: 0.
7882 - val_loss: 0.5015 - val_accuracy: 0.7642
Epoch 26/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4405 - accuracy: 0.
8024 - val_loss: 0.5001 - val_accuracy: 0.7805
Epoch 27/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4402 - accuracy: 0.
7963 - val_loss: 0.5091 - val_accuracy: 0.7805
Epoch 28/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4304 - accuracy: 0.
7984 - val_loss: 0.5013 - val_accuracy: 0.7886
Epoch 29/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4371 - accuracy: 0.
7923 - val_loss: 0.5005 - val_accuracy: 0.7886
Epoch 30/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4370 - accuracy: 0.
8086 - val_loss: 0.5139 - val_accuracy: 0.7886
Epoch 31/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4323 - accuracy: 0.
8024 - val_loss: 0.5056 - val_accuracy: 0.7886
Epoch 32/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4414 - accuracy: 0.
8045 - val_loss: 0.5024 - val_accuracy: 0.7805
Epoch 33/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4296 - accuracy: 0.
8004 - val_loss: 0.5009 - val_accuracy: 0.7967
Epoch 34/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4381 - accuracy: 0.
7963 - val_loss: 0.5056 - val_accuracy: 0.7886
Epoch 35/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4253 - accuracy: 0.
8167 - val_loss: 0.5065 - val_accuracy: 0.7724
Epoch 36/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4184 - accuracy: 0.
8248 - val_loss: 0.5081 - val_accuracy: 0.7886
Epoch 37/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4167 - accuracy: 0.
8187 - val_loss: 0.5124 - val_accuracy: 0.7724
Epoch 38/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4231 - accuracy: 0.
8269 - val_loss: 0.5122 - val_accuracy: 0.7805
Epoch 39/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4160 - accuracy: 0.
8167 - val_loss: 0.5109 - val_accuracy: 0.7642
Epoch 40/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4144 - accuracy: 0.
8167 - val_loss: 0.5178 - val_accuracy: 0.7886
Epoch 41/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4115 - accuracy: 0.
8208 - val_loss: 0.5161 - val_accuracy: 0.7805
Epoch 42/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4066 - accuracy: 0.
8208 - val_loss: 0.5196 - val_accuracy: 0.7805
Epoch 43/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4094 - accuracy: 0.
```

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8269 - val_loss: 0.5219 - val_accuracy: 0.7642
Epoch 44/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4282 - accuracy: 0.
8147 - val_loss: 0.5205 - val_accuracy: 0.7805
Epoch 45/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4058 - accuracy: 0.
8228 - val_loss: 0.5079 - val_accuracy: 0.7642
Epoch 46/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4036 - accuracy: 0.
8147 - val_loss: 0.5219 - val_accuracy: 0.7642
Epoch 47/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4090 - accuracy: 0.
8187 - val_loss: 0.5380 - val_accuracy: 0.7724
Epoch 48/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4059 - accuracy: 0.
8289 - val_loss: 0.5149 - val_accuracy: 0.7724
Epoch 49/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3986 - accuracy: 0.
8248 - val_loss: 0.5290 - val_accuracy: 0.7967
Epoch 50/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4013 - accuracy: 0.
8248 - val_loss: 0.5195 - val_accuracy: 0.7724
```

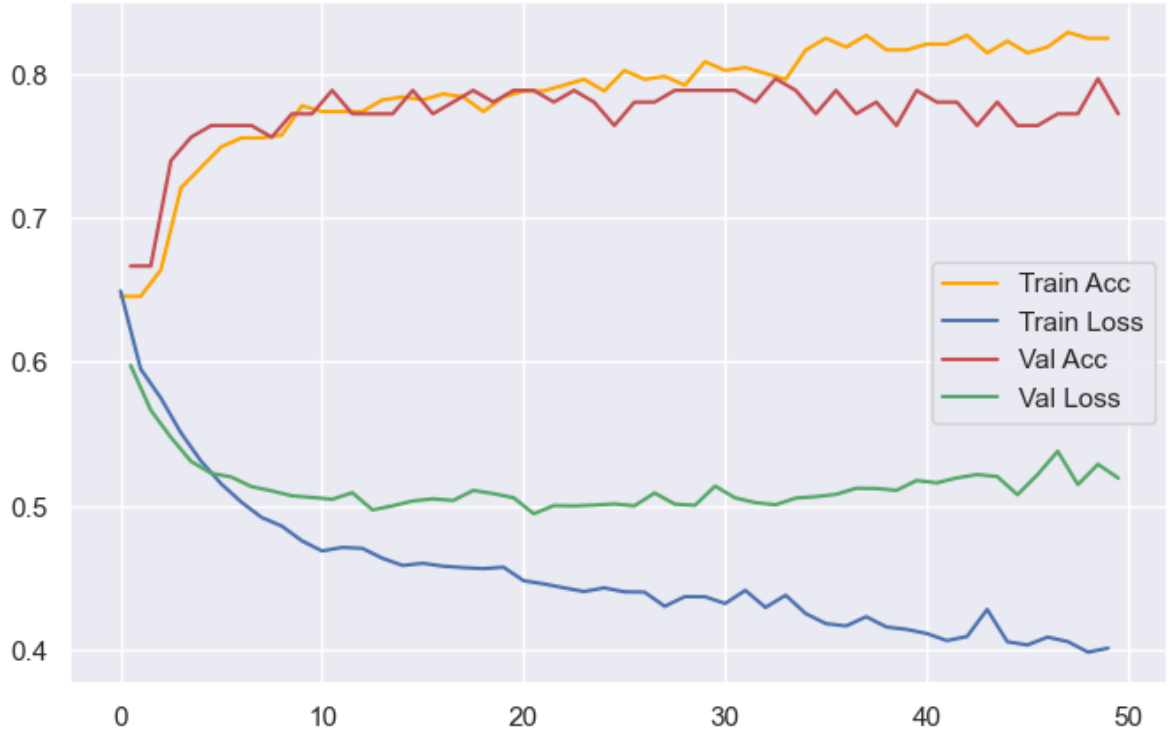

```
Epoch 1/50
16/16 [==============================] - 0s 7ms/step - loss: 0.6347 - accuracy: 0.
6477 - val_loss: 0.5767 - val_accuracy: 0.6667
Epoch 2/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5917 - accuracy: 0.
6477 - val_loss: 0.5434 - val_accuracy: 0.6504
Epoch 3/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5711 - accuracy: 0.
6497 - val_loss: 0.5211 - val_accuracy: 0.7642
Epoch 4/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5521 - accuracy: 0.
7108 - val_loss: 0.4976 - val_accuracy: 0.7967
Epoch 5/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5422 - accuracy: 0.
7149 - val_loss: 0.5005 - val_accuracy: 0.7317
Epoch 6/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5306 - accuracy: 0.
7291 - val_loss: 0.4897 - val_accuracy: 0.7398
Epoch 7/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5259 - accuracy: 0.
7373 - val_loss: 0.4789 - val_accuracy: 0.8130
Epoch 8/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5179 - accuracy: 0.
7271 - val_loss: 0.4922 - val_accuracy: 0.7642
Epoch 9/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5189 - accuracy: 0.
7434 - val_loss: 0.4798 - val_accuracy: 0.7724
Epoch 10/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5068 - accuracy: 0.
7352 - val_loss: 0.4778 - val_accuracy: 0.8211
Epoch 11/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5118 - accuracy: 0.
7312 - val_loss: 0.5141 - val_accuracy: 0.7724
Epoch 12/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5083 - accuracy: 0.
7332 - val_loss: 0.4970 - val_accuracy: 0.7724
Epoch 13/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4972 - accuracy: 0.
7434 - val_loss: 0.4721 - val_accuracy: 0.7886
Epoch 14/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4970 - accuracy: 0.
7434 - val_loss: 0.4901 - val_accuracy: 0.7724
Epoch 15/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4924 - accuracy: 0.
7475 - val_loss: 0.4759 - val_accuracy: 0.7886
Epoch 16/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4964 - accuracy: 0.
7393 - val_loss: 0.4711 - val_accuracy: 0.7967
Epoch 17/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4963 - accuracy: 0.
7352 - val_loss: 0.4744 - val_accuracy: 0.7805
Epoch 18/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4880 - accuracy: 0.
7597 - val_loss: 0.4827 - val_accuracy: 0.7886
Epoch 19/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4868 - accuracy: 0.
7495 - val_loss: 0.4852 - val_accuracy: 0.7886
Epoch 20/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4824 - accuracy: 0.
7556 - val_loss: 0.4845 - val_accuracy: 0.7642
Epoch 21/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4869 - accuracy: 0.
7617 - val_loss: 0.4826 - val_accuracy: 0.7886
Epoch 22/50
```

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16/16 [==============================] - 0s 2ms/step - loss: 0.4790 - accuracy: 0.
7515 - val_loss: 0.4903 - val_accuracy: 0.7805
Epoch 23/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4783 - accuracy: 0.
7495 - val_loss: 0.5347 - val_accuracy: 0.7317
Epoch 24/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4797 - accuracy: 0.
7536 - val_loss: 0.4896 - val_accuracy: 0.7724
Epoch 25/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4811 - accuracy: 0.
7576 - val_loss: 0.4818 - val_accuracy: 0.7886
Epoch 26/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4754 - accuracy: 0.
7454 - val_loss: 0.5041 - val_accuracy: 0.7561
Epoch 27/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4766 - accuracy: 0.
7413 - val_loss: 0.5289 - val_accuracy: 0.7480
Epoch 28/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4726 - accuracy: 0.
7597 - val_loss: 0.4871 - val_accuracy: 0.7561
Epoch 29/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4752 - accuracy: 0.
7678 - val_loss: 0.4744 - val_accuracy: 0.7561
Epoch 30/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4655 - accuracy: 0.
7576 - val_loss: 0.5619 - val_accuracy: 0.7236
Epoch 31/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4731 - accuracy: 0.
7658 - val_loss: 0.4744 - val_accuracy: 0.7642
Epoch 32/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4703 - accuracy: 0.
7556 - val_loss: 0.5333 - val_accuracy: 0.7480
Epoch 33/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4697 - accuracy: 0.
7556 - val_loss: 0.4716 - val_accuracy: 0.7805
Epoch 34/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4671 - accuracy: 0.
7678 - val_loss: 0.4773 - val_accuracy: 0.7724
Epoch 35/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4780 - accuracy: 0.
7597 - val_loss: 0.5091 - val_accuracy: 0.7642
Epoch 36/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4684 - accuracy: 0.
7454 - val_loss: 0.4779 - val_accuracy: 0.7724
Epoch 37/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4614 - accuracy: 0.
7617 - val_loss: 0.4705 - val_accuracy: 0.7805
Epoch 38/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4637 - accuracy: 0.
7780 - val_loss: 0.4701 - val_accuracy: 0.7805
Epoch 39/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4553 - accuracy: 0.
7617 - val_loss: 0.4956 - val_accuracy: 0.7642
Epoch 40/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4548 - accuracy: 0.
7780 - val_loss: 0.4712 - val_accuracy: 0.7805
Epoch 41/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4683 - accuracy: 0.
7658 - val_loss: 0.4709 - val_accuracy: 0.7561
Epoch 42/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4538 - accuracy: 0.
7699 - val_loss: 0.4971 - val_accuracy: 0.7561
Epoch 43/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4599 - accuracy: 0.
```

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7719 - val_loss: 0.4730 - val_accuracy: 0.7561
Epoch 44/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4558 - accuracy: 0.
7637 - val_loss: 0.4922 - val_accuracy: 0.7561
Epoch 45/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4574 - accuracy: 0.
7800 - val_loss: 0.4692 - val_accuracy: 0.7805
Epoch 46/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4532 - accuracy: 0.
7902 - val_loss: 0.4739 - val_accuracy: 0.7561
Epoch 47/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4511 - accuracy: 0.
7882 - val_loss: 0.4819 - val_accuracy: 0.7642
Epoch 48/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4497 - accuracy: 0.
7739 - val_loss: 0.4633 - val_accuracy: 0.7724
Epoch 49/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4538 - accuracy: 0.
7678 - val_loss: 0.5019 - val_accuracy: 0.7642
Epoch 50/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4481 - accuracy: 0.
7719 - val_loss: 0.4678 - val_accuracy: 0.7886
```
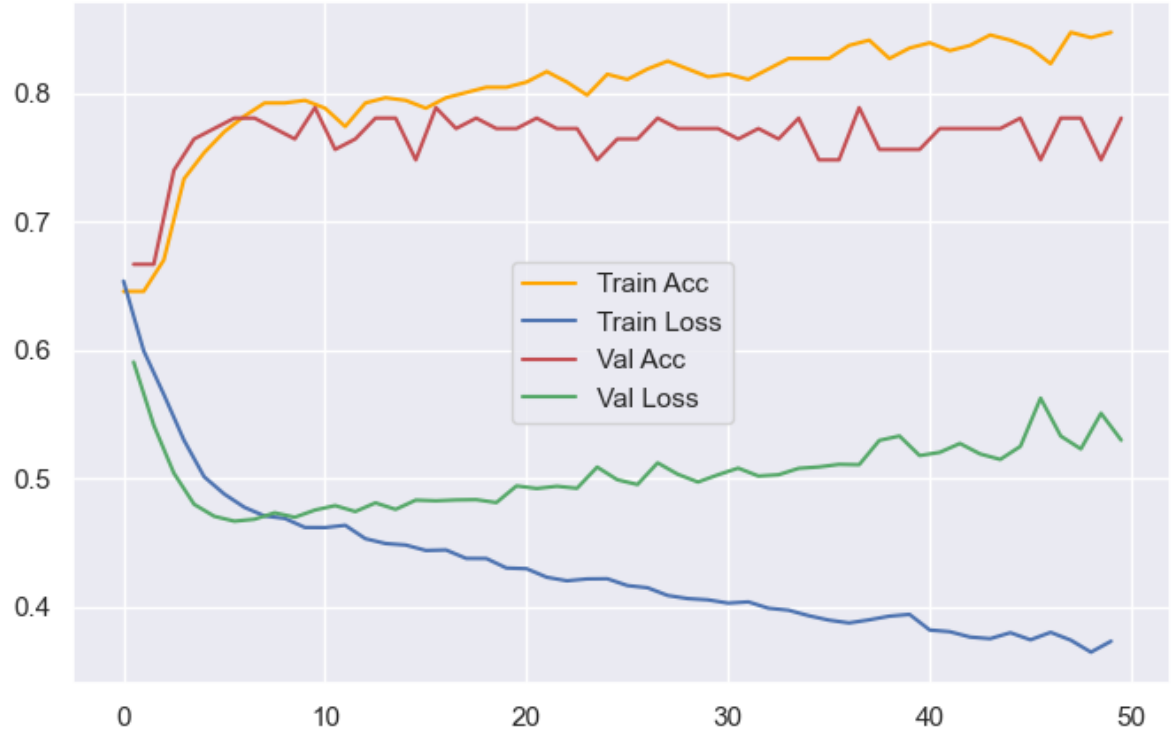

```
Epoch 1/50
16/16 [==============================] - 1s 7ms/step - loss: 0.6536 - accuracy: 0.
6456 - val_loss: 0.5906 - val_accuracy: 0.6667
Epoch 2/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5994 - accuracy: 0.
6456 - val_loss: 0.5414 - val_accuracy: 0.6667
Epoch 3/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5653 - accuracy: 0.
6701 - val_loss: 0.5040 - val_accuracy: 0.7398
Epoch 4/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5297 - accuracy: 0.
7332 - val_loss: 0.4799 - val_accuracy: 0.7642
Epoch 5/50
16/16 [==============================] - 0s 2ms/step - loss: 0.5013 - accuracy: 0.
7536 - val_loss: 0.4705 - val_accuracy: 0.7724
Epoch 6/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4878 - accuracy: 0.
7699 - val_loss: 0.4667 - val_accuracy: 0.7805
Epoch 7/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4775 - accuracy: 0.
7821 - val_loss: 0.4682 - val_accuracy: 0.7805
Epoch 8/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4707 - accuracy: 0.
7923 - val_loss: 0.4732 - val_accuracy: 0.7724
Epoch 9/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4688 - accuracy: 0.
7923 - val_loss: 0.4697 - val_accuracy: 0.7642
Epoch 10/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4618 - accuracy: 0.
7943 - val_loss: 0.4754 - val_accuracy: 0.7886
Epoch 11/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4617 - accuracy: 0.
7882 - val_loss: 0.4788 - val_accuracy: 0.7561
Epoch 12/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4635 - accuracy: 0.
7739 - val_loss: 0.4742 - val_accuracy: 0.7642
Epoch 13/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4531 - accuracy: 0.
7923 - val_loss: 0.4810 - val_accuracy: 0.7805
Epoch 14/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4493 - accuracy: 0.
7963 - val_loss: 0.4759 - val_accuracy: 0.7805
Epoch 15/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4481 - accuracy: 0.
7943 - val_loss: 0.4831 - val_accuracy: 0.7480
Epoch 16/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4439 - accuracy: 0.
7882 - val_loss: 0.4826 - val_accuracy: 0.7886
Epoch 17/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4443 - accuracy: 0.
7963 - val_loss: 0.4832 - val_accuracy: 0.7724
Epoch 18/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4377 - accuracy: 0.
8004 - val_loss: 0.4834 - val_accuracy: 0.7805
Epoch 19/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4376 - accuracy: 0.
8045 - val_loss: 0.4812 - val_accuracy: 0.7724
Epoch 20/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4302 - accuracy: 0.
8045 - val_loss: 0.4942 - val_accuracy: 0.7724
Epoch 21/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4297 - accuracy: 0.
8086 - val_loss: 0.4921 - val_accuracy: 0.7805
Epoch 22/50
```

```
16/16 [==============================] - 0s 2ms/step - loss: 0.4230 - accuracy: 0.
8167 - val_loss: 0.4939 - val_accuracy: 0.7724
Epoch 23/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4203 - accuracy: 0.
8086 - val_loss: 0.4923 - val_accuracy: 0.7724
Epoch 24/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4218 - accuracy: 0.
7984 - val_loss: 0.5088 - val_accuracy: 0.7480
Epoch 25/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4219 - accuracy: 0.
8147 - val_loss: 0.4989 - val_accuracy: 0.7642
Epoch 26/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4166 - accuracy: 0.
8106 - val_loss: 0.4952 - val_accuracy: 0.7642
Epoch 27/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4149 - accuracy: 0.
8187 - val_loss: 0.5121 - val_accuracy: 0.7805
Epoch 28/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4089 - accuracy: 0.
8248 - val_loss: 0.5032 - val_accuracy: 0.7724
Epoch 29/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4064 - accuracy: 0.
8187 - val_loss: 0.4972 - val_accuracy: 0.7724
Epoch 30/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4055 - accuracy: 0.
8126 - val_loss: 0.5028 - val_accuracy: 0.7724
Epoch 31/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4029 - accuracy: 0.
8147 - val_loss: 0.5080 - val_accuracy: 0.7642
Epoch 32/50
16/16 [==============================] - 0s 2ms/step - loss: 0.4039 - accuracy: 0.
8106 - val_loss: 0.5018 - val_accuracy: 0.7724
Epoch 33/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3989 - accuracy: 0.
8187 - val_loss: 0.5028 - val_accuracy: 0.7642
Epoch 34/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3974 - accuracy: 0.
8269 - val_loss: 0.5078 - val_accuracy: 0.7805
Epoch 35/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3931 - accuracy: 0.
8269 - val_loss: 0.5089 - val_accuracy: 0.7480
Epoch 36/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3897 - accuracy: 0.
8269 - val_loss: 0.5109 - val_accuracy: 0.7480
Epoch 37/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3875 - accuracy: 0.
8371 - val_loss: 0.5106 - val_accuracy: 0.7886
Epoch 38/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3899 - accuracy: 0.
8411 - val_loss: 0.5296 - val_accuracy: 0.7561
Epoch 39/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3928 - accuracy: 0.
8269 - val_loss: 0.5330 - val_accuracy: 0.7561
Epoch 40/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3941 - accuracy: 0.
8350 - val_loss: 0.5178 - val_accuracy: 0.7561
Epoch 41/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3819 - accuracy: 0.
8391 - val_loss: 0.5203 - val_accuracy: 0.7724
Epoch 42/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3807 - accuracy: 0.
8330 - val_loss: 0.5272 - val_accuracy: 0.7724
Epoch 43/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3765 - accuracy: 0.
```

```
8371 - val_loss: 0.5190 - val_accuracy: 0.7724
Epoch 44/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3752 - accuracy: 0.
8452 - val_loss: 0.5148 - val_accuracy: 0.7724
Epoch 45/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3799 - accuracy: 0.
8411 - val_loss: 0.5249 - val_accuracy: 0.7805
Epoch 46/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3743 - accuracy: 0.
8350 - val_loss: 0.5625 - val_accuracy: 0.7480
Epoch 47/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3802 - accuracy: 0.
8228 - val_loss: 0.5330 - val_accuracy: 0.7805
Epoch 48/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3741 - accuracy: 0.
8473 - val_loss: 0.5229 - val_accuracy: 0.7805
Epoch 49/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3647 - accuracy: 0.
8432 - val_loss: 0.5507 - val_accuracy: 0.7480
Epoch 50/50
16/16 [==============================] - 0s 2ms/step - loss: 0.3733 - accuracy: 0.
8473 - val_loss: 0.5298 - val_accuracy: 0.7805
```




```
[[0.6666666865348816], [0.7967479825019836], [0.8211382031440735], [0.788617908954
6204]]
```

In [9]:
```
# final model
final_val_acc, final_history, final_model=implement(hiddensizes[:2], actfn, optimi
scores = final_model.evaluate(X_train, y_train)
print("Training Accuracy: %.2f%%\n" % (scores[1]*100))

scores = final_model.evaluate(X_test, y_test)
print("Testing Accuracy: %.2f%%\n" % (scores[1]*100))
```

```
Epoch 1/100
16/16 [==============================] - 1s 7ms/step - loss: 0.6433 - accuracy: 0.
6456 - val_loss: 0.5596 - val_accuracy: 0.6748
Epoch 2/100
16/16 [==============================] - 0s 2ms/step - loss: 0.5276 - accuracy: 0.
7291 - val_loss: 0.5062 - val_accuracy: 0.7398
Epoch 3/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4883 - accuracy: 0.
7739 - val_loss: 0.4952 - val_accuracy: 0.7886
Epoch 4/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4863 - accuracy: 0.
7576 - val_loss: 0.4853 - val_accuracy: 0.8049
Epoch 5/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4724 - accuracy: 0.
7800 - val_loss: 0.4910 - val_accuracy: 0.7805
Epoch 6/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4766 - accuracy: 0.
7597 - val_loss: 0.5336 - val_accuracy: 0.7398
Epoch 7/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4659 - accuracy: 0.
7841 - val_loss: 0.4855 - val_accuracy: 0.7642
Epoch 8/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4611 - accuracy: 0.
7841 - val_loss: 0.4839 - val_accuracy: 0.7886
Epoch 9/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4558 - accuracy: 0.
7780 - val_loss: 0.5123 - val_accuracy: 0.7561
Epoch 10/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4550 - accuracy: 0.
7739 - val_loss: 0.5004 - val_accuracy: 0.7805
Epoch 11/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4579 - accuracy: 0.
7617 - val_loss: 0.4938 - val_accuracy: 0.7642
Epoch 12/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4529 - accuracy: 0.
7780 - val_loss: 0.4776 - val_accuracy: 0.7724
Epoch 13/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4447 - accuracy: 0.
7699 - val_loss: 0.5124 - val_accuracy: 0.7480
Epoch 14/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4411 - accuracy: 0.
7800 - val_loss: 0.4935 - val_accuracy: 0.7724
Epoch 15/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4324 - accuracy: 0.
7882 - val_loss: 0.5156 - val_accuracy: 0.7724
Epoch 16/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4362 - accuracy: 0.
7862 - val_loss: 0.5498 - val_accuracy: 0.7561
Epoch 17/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4394 - accuracy: 0.
7760 - val_loss: 0.5362 - val_accuracy: 0.7724
Epoch 18/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4282 - accuracy: 0.
7800 - val_loss: 0.5105 - val_accuracy: 0.7317
Epoch 19/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4279 - accuracy: 0.
7923 - val_loss: 0.4899 - val_accuracy: 0.7642
Epoch 20/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4265 - accuracy: 0.
7923 - val_loss: 0.5101 - val_accuracy: 0.7398
Epoch 21/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4221 - accuracy: 0.
8065 - val_loss: 0.5028 - val_accuracy: 0.7805
Epoch 22/100
```

```
16/16 [==============================] - 0s 2ms/step - loss: 0.4189 - accuracy: 0.
7923 - val_loss: 0.5073 - val_accuracy: 0.7398
Epoch 23/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4170 - accuracy: 0.
7943 - val_loss: 0.4964 - val_accuracy: 0.7398
Epoch 24/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4021 - accuracy: 0.
7984 - val_loss: 0.5550 - val_accuracy: 0.7724
Epoch 25/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4097 - accuracy: 0.
7943 - val_loss: 0.4969 - val_accuracy: 0.7642
Epoch 26/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4069 - accuracy: 0.
8065 - val_loss: 0.4886 - val_accuracy: 0.7724
Epoch 27/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3995 - accuracy: 0.
8045 - val_loss: 0.5082 - val_accuracy: 0.7480
Epoch 28/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3948 - accuracy: 0.
8269 - val_loss: 0.5313 - val_accuracy: 0.7561
Epoch 29/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3985 - accuracy: 0.
8167 - val_loss: 0.5092 - val_accuracy: 0.7154
Epoch 30/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3840 - accuracy: 0.
8147 - val_loss: 0.5049 - val_accuracy: 0.7805
Epoch 31/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3895 - accuracy: 0.
8106 - val_loss: 0.5250 - val_accuracy: 0.7642
Epoch 32/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3893 - accuracy: 0.
8106 - val_loss: 0.5395 - val_accuracy: 0.7561
Epoch 33/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3783 - accuracy: 0.
8126 - val_loss: 0.5437 - val_accuracy: 0.7642
Epoch 34/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3874 - accuracy: 0.
8167 - val_loss: 0.4976 - val_accuracy: 0.7805
Epoch 35/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3927 - accuracy: 0.
8187 - val_loss: 0.5513 - val_accuracy: 0.7317
Epoch 36/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3817 - accuracy: 0.
8187 - val_loss: 0.5486 - val_accuracy: 0.7398
Epoch 37/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3817 - accuracy: 0.
8126 - val_loss: 0.5211 - val_accuracy: 0.7398
Epoch 38/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3625 - accuracy: 0.
8208 - val_loss: 0.5501 - val_accuracy: 0.7886
Epoch 39/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3741 - accuracy: 0.
8126 - val_loss: 0.5253 - val_accuracy: 0.7317
Epoch 40/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3803 - accuracy: 0.
8065 - val_loss: 0.5719 - val_accuracy: 0.7480
Epoch 41/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3685 - accuracy: 0.
8228 - val_loss: 0.6294 - val_accuracy: 0.7561
Epoch 42/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3662 - accuracy: 0.
8248 - val_loss: 0.5602 - val_accuracy: 0.7317
Epoch 43/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3598 - accuracy: 0.
```

```
8269 - val_loss: 0.5931 - val_accuracy: 0.7480
Epoch 44/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3515 - accuracy: 0.
8350 - val_loss: 0.5496 - val_accuracy: 0.7236
Epoch 45/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3467 - accuracy: 0.
8411 - val_loss: 0.6189 - val_accuracy: 0.7480
Epoch 46/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3606 - accuracy: 0.
8289 - val_loss: 0.5942 - val_accuracy: 0.7073
Epoch 47/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3519 - accuracy: 0.
8289 - val_loss: 0.5661 - val_accuracy: 0.7561
Epoch 48/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3477 - accuracy: 0.
8350 - val_loss: 0.5724 - val_accuracy: 0.7317
Epoch 49/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3467 - accuracy: 0.
8371 - val_loss: 0.5743 - val_accuracy: 0.7480
Epoch 50/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3502 - accuracy: 0.
8371 - val_loss: 0.5867 - val_accuracy: 0.7561
Epoch 51/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3447 - accuracy: 0.
8371 - val_loss: 0.5777 - val_accuracy: 0.7398
Epoch 52/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3276 - accuracy: 0.
8635 - val_loss: 0.5995 - val_accuracy: 0.7561
Epoch 53/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3326 - accuracy: 0.
8330 - val_loss: 0.6709 - val_accuracy: 0.7154
Epoch 54/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3367 - accuracy: 0.
8452 - val_loss: 0.5977 - val_accuracy: 0.7154
Epoch 55/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3517 - accuracy: 0.
8411 - val_loss: 0.5946 - val_accuracy: 0.7480
Epoch 56/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3280 - accuracy: 0.
8411 - val_loss: 0.5943 - val_accuracy: 0.7642
Epoch 57/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3300 - accuracy: 0.
8554 - val_loss: 0.6382 - val_accuracy: 0.7317
Epoch 58/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3200 - accuracy: 0.
8513 - val_loss: 0.6197 - val_accuracy: 0.7480
Epoch 59/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3411 - accuracy: 0.
8411 - val_loss: 0.6527 - val_accuracy: 0.7398
Epoch 60/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3254 - accuracy: 0.
8473 - val_loss: 0.6814 - val_accuracy: 0.7317
Epoch 61/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3266 - accuracy: 0.
8513 - val_loss: 0.6276 - val_accuracy: 0.7561
Epoch 62/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3512 - accuracy: 0.
8371 - val_loss: 0.6208 - val_accuracy: 0.7317
Epoch 63/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3192 - accuracy: 0.
8595 - val_loss: 0.6477 - val_accuracy: 0.7317
Epoch 64/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3153 - accuracy: 0.
8534 - val_loss: 0.6648 - val_accuracy: 0.7073
```

```
Epoch 65/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3278 - accuracy: 0.
8310 - val_loss: 0.6287 - val_accuracy: 0.7236
Epoch 66/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3113 - accuracy: 0.
8452 - val_loss: 0.7039 - val_accuracy: 0.7398
Epoch 67/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3166 - accuracy: 0.
8432 - val_loss: 0.6628 - val_accuracy: 0.7317
Epoch 68/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3139 - accuracy: 0.
8452 - val_loss: 0.6029 - val_accuracy: 0.7480
Epoch 69/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3204 - accuracy: 0.
8411 - val_loss: 0.6722 - val_accuracy: 0.7236
Epoch 70/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3084 - accuracy: 0.
8574 - val_loss: 0.6535 - val_accuracy: 0.7398
Epoch 71/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3268 - accuracy: 0.
8432 - val_loss: 0.6502 - val_accuracy: 0.7236
Epoch 72/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3151 - accuracy: 0.
8411 - val_loss: 0.7717 - val_accuracy: 0.7561
Epoch 73/100
16/16 [==============================] - 0s 2ms/step - loss: 0.4065 - accuracy: 0.
8106 - val_loss: 0.6423 - val_accuracy: 0.6911
Epoch 74/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3716 - accuracy: 0.
8187 - val_loss: 0.5880 - val_accuracy: 0.7317
Epoch 75/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3501 - accuracy: 0.
8350 - val_loss: 0.5976 - val_accuracy: 0.7480
Epoch 76/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3397 - accuracy: 0.
8391 - val_loss: 0.6129 - val_accuracy: 0.7398
Epoch 77/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3336 - accuracy: 0.
8473 - val_loss: 0.6423 - val_accuracy: 0.7236
Epoch 78/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3311 - accuracy: 0.
8350 - val_loss: 0.6174 - val_accuracy: 0.6992
Epoch 79/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3421 - accuracy: 0.
8289 - val_loss: 0.6561 - val_accuracy: 0.7317
Epoch 80/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3411 - accuracy: 0.
8350 - val_loss: 0.6562 - val_accuracy: 0.7561
Epoch 81/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3192 - accuracy: 0.
8615 - val_loss: 0.6052 - val_accuracy: 0.7480
Epoch 82/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3262 - accuracy: 0.
8595 - val_loss: 0.6578 - val_accuracy: 0.7073
Epoch 83/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3101 - accuracy: 0.
8697 - val_loss: 0.6619 - val_accuracy: 0.7317
Epoch 84/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3212 - accuracy: 0.
8595 - val_loss: 0.6345 - val_accuracy: 0.7398
Epoch 85/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3096 - accuracy: 0.
8493 - val_loss: 0.6604 - val_accuracy: 0.7317
Epoch 86/100
```

```
16/16 [==============================] - 0s 2ms/step - loss: 0.3026 - accuracy: 0.
8697 - val_loss: 0.6480 - val_accuracy: 0.7561
Epoch 87/100
16/16 [==============================] - 0s 2ms/step - loss: 0.2967 - accuracy: 0.
8595 - val_loss: 0.6502 - val_accuracy: 0.7480
Epoch 88/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3083 - accuracy: 0.
8595 - val_loss: 0.6809 - val_accuracy: 0.7073
Epoch 89/100
16/16 [==============================] - 0s 2ms/step - loss: 0.2982 - accuracy: 0.
8513 - val_loss: 0.6784 - val_accuracy: 0.7236
Epoch 90/100
16/16 [==============================] - 0s 2ms/step - loss: 0.2916 - accuracy: 0.
8554 - val_loss: 0.7345 - val_accuracy: 0.7073
Epoch 91/100
16/16 [==============================] - 0s 2ms/step - loss: 0.2907 - accuracy: 0.
8574 - val_loss: 0.6814 - val_accuracy: 0.7154
Epoch 92/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3011 - accuracy: 0.
8574 - val_loss: 0.6738 - val_accuracy: 0.7561
Epoch 93/100
16/16 [==============================] - 0s 2ms/step - loss: 0.2994 - accuracy: 0.
8493 - val_loss: 0.7644 - val_accuracy: 0.7398
Epoch 94/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3605 - accuracy: 0.
8432 - val_loss: 0.7344 - val_accuracy: 0.7317
Epoch 95/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3908 - accuracy: 0.
8350 - val_loss: 0.6767 - val_accuracy: 0.7317
Epoch 96/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3719 - accuracy: 0.
8310 - val_loss: 0.7053 - val_accuracy: 0.7236
Epoch 97/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3467 - accuracy: 0.
8371 - val_loss: 0.6965 - val_accuracy: 0.7154
Epoch 98/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3126 - accuracy: 0.
8513 - val_loss: 0.6576 - val_accuracy: 0.7317
Epoch 99/100
16/16 [==============================] - 0s 2ms/step - loss: 0.2987 - accuracy: 0.
8635 - val_loss: 0.7522 - val_accuracy: 0.7154
Epoch 100/100
16/16 [==============================] - 0s 2ms/step - loss: 0.3043 - accuracy: 0.
8554 - val_loss: 0.7178 - val_accuracy: 0.7317
16/16 [==============================] - 0s 533us/step - loss: 0.2836 - accuracy:
0.8615
Training Accuracy: 86.15%

5/5 [==============================] - 0s 750us/step - loss: 0.7563 - accuracy: 0.
7208
Testing Accuracy: 72.08%
```

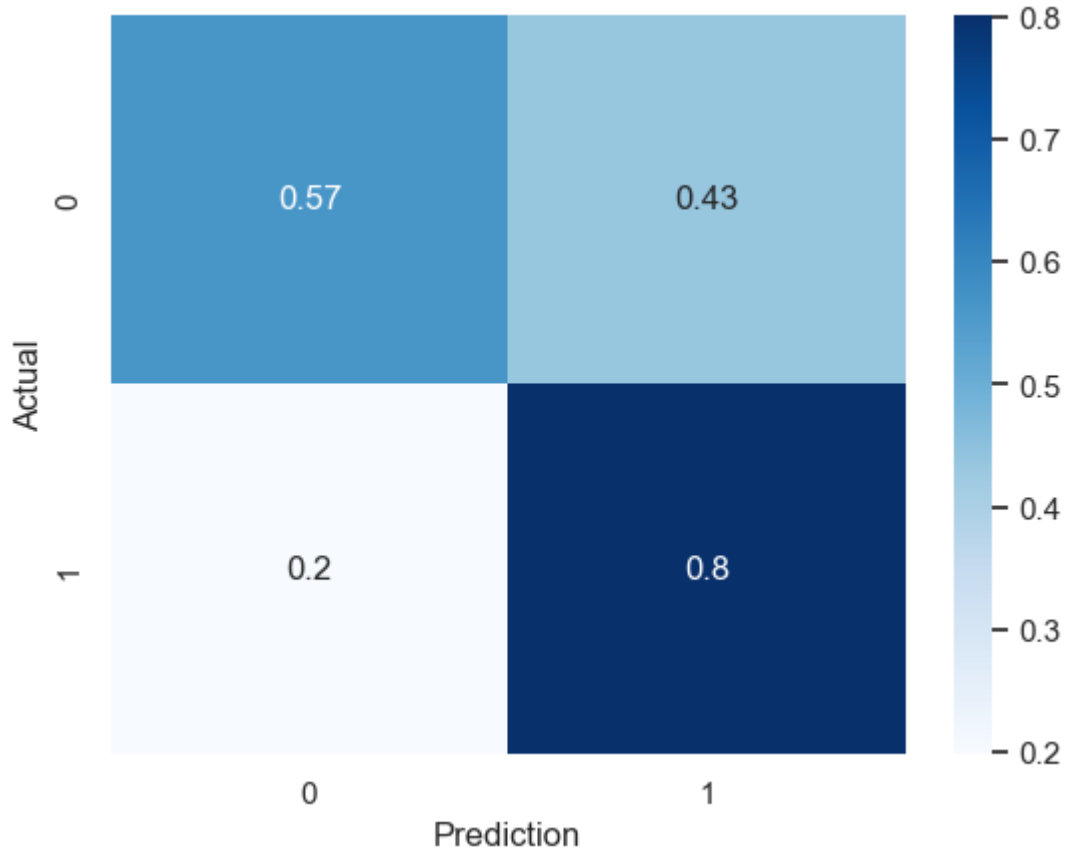
In [10]:

```
from sklearn.metrics import confusion_matrix
import seaborn as sns

y_test_pred = (final_model.predict(X_test)>0.5).astype(int)
c_mat = confusion_matrix(y_test, y_test_pred, normalize='true')
ax = sns.heatmap(c_mat, annot=True,
                 cmap='Blues')
ax.set_xlabel("Prediction")
ax.set_ylabel("Actual")
```

```
5/5 [==============================] - 0s 1ms/step
```

Out[10]:

```
Text(47.25, 0.5, 'Actual')
```



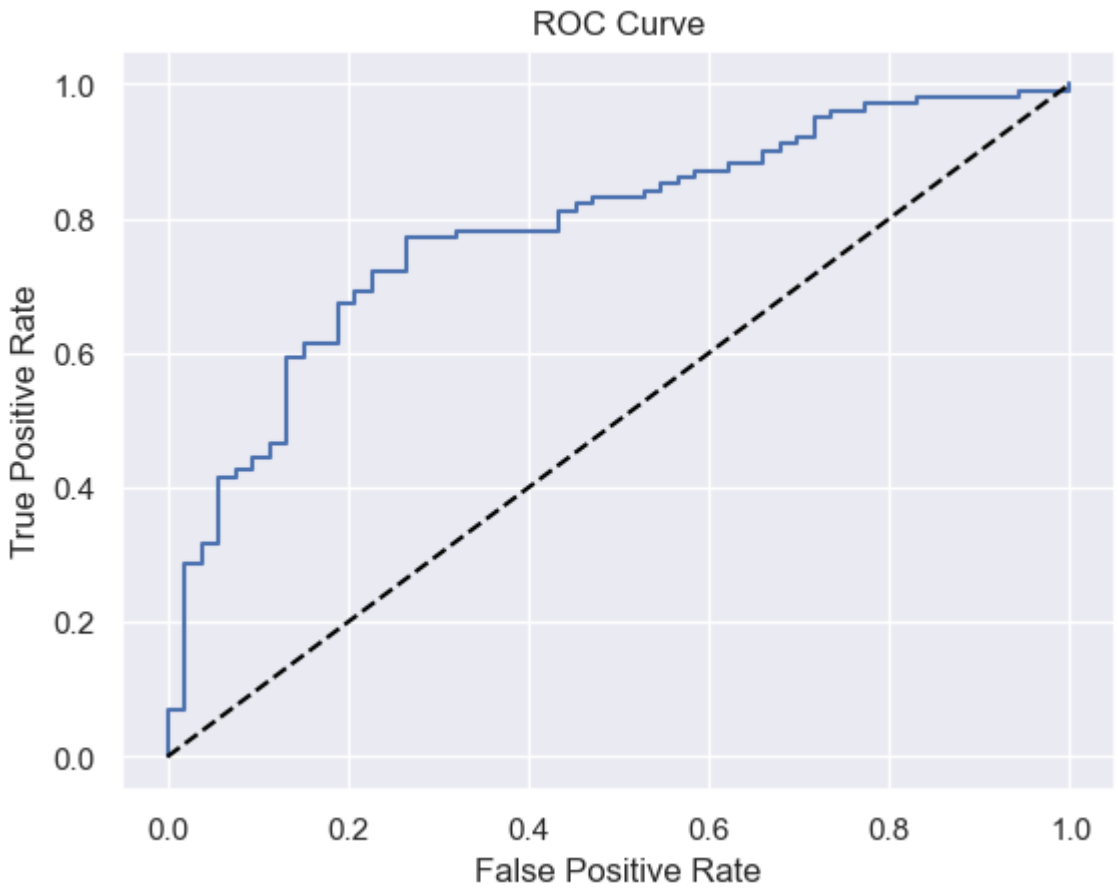
In [11]:

```
from sklearn.metrics import roc_curve
import matplotlib.pyplot as plt

y_test_pred_probs = final_model.predict(X_test)
FPR, TPR, _ = roc_curve(y_test, y_test_pred_probs)
plt.plot(FPR, TPR)
plt.plot([0,1],[0,1],'--', color='black') #diagonal line
plt.title('ROC Curve')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
```

```
5/5 [==============================] - 0s 1000us/step
```

Out[11]:

```
Text(0, 0.5, 'True Positive Rate')
```



In [12]:
```
from sklearn.metrics import roc_auc_score

roc_auc = roc_auc_score(y_test, y_test_pred_probs)

print("ROC AUC Score:", roc_auc)
```

```
ROC AUC Score: 0.785354007098823
```