Import necessarry library dependencies

In [1]:

```
import tensorflow as tf
from tensorflow.keras import layers, models
from tensorflow.keras.applications import EfficientNetV2B0
from tensorflow.keras.applications.efficientnet import preprocess_input
from sklearn.metrics import confusion_matrix, classification_report
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
```

Import datasets

In [2]:

```
#Dataset paths
trainpath = r'/content/drive/MyDrive/modified-dataset/train'
validpath = r'/content/drive/MyDrive/modified-dataset/val'
testpath  = r'/content/drive/MyDrive/modified-dataset/test'
```

Understand the Data

In [3]:

```
# 1EXPLORE AND UNDERSTAND THE DATA
IMG_SIZE = (128, 128)
BATCH_SIZE = 32

datatrain = tf.keras.utils.image_dataset_from_directory(trainpath, shuffle=True
datavalid = tf.keras.utils.image_dataset_from_directory(validpath, shuffle=True
datatest  = tf.keras.utils.image_dataset_from_directory(testpath, shuffle=False

class_names = datatrain.class_names
print(f"Classes: {class_names}")
```

```
Found 2410 files belonging to 10 classes.
Found 300 files belonging to 10 classes.
Found 310 files belonging to 10 classes.
Classes: ['Battery', 'Keyboard', 'Microwave', 'Mobile', 'Mouse', 'PCB', 'Player',
'Printer', 'Television', 'Washing Machine']
```

Visualize samples

In [4]:

```
# Visualize samples
plt.figure(figsize=(10,10))
for images, labels in datatrain.take(1):
    for i in range(9):
        ax = plt.subplot(3,3,i+1)
```

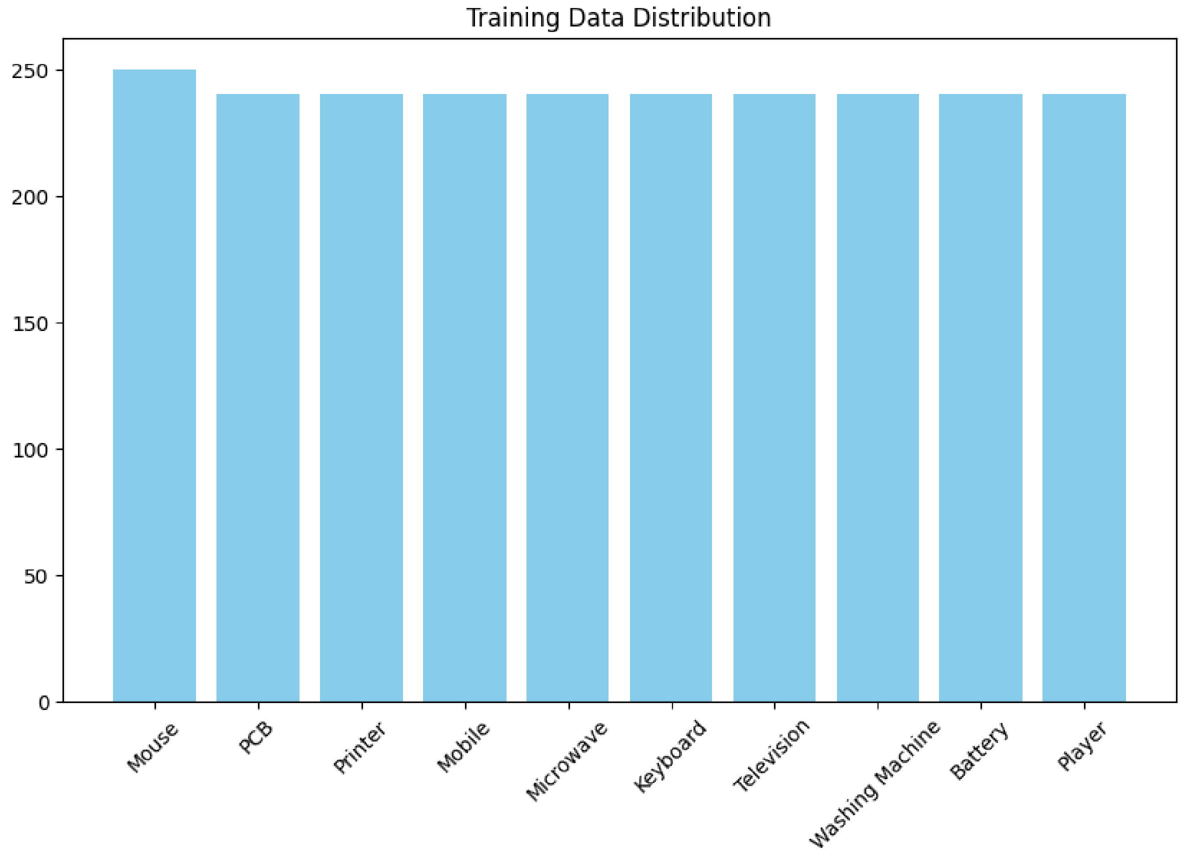
```
        plt.imshow(images[i].numpy().astype("uint8"))
        plt.title(class_names[labels[i]])
        plt.axis("off")
plt.show()
```

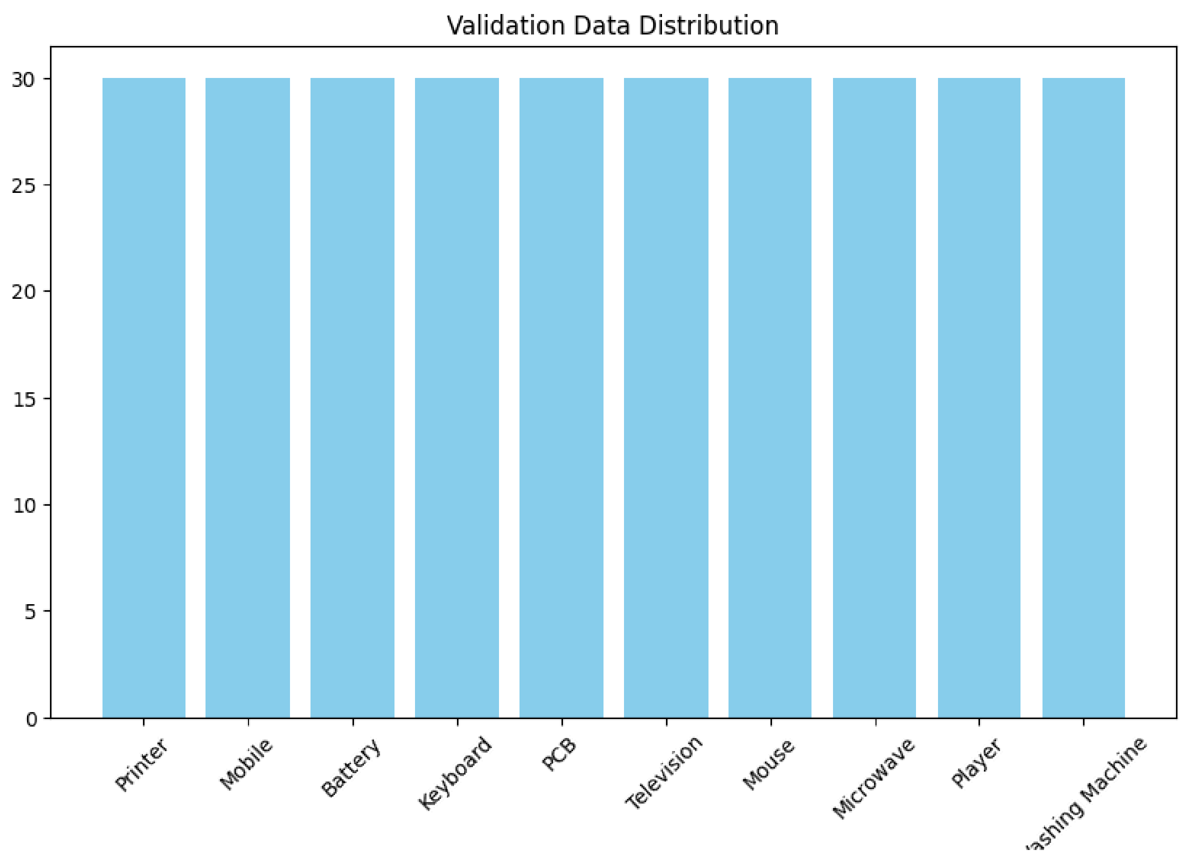
Plot class distribution

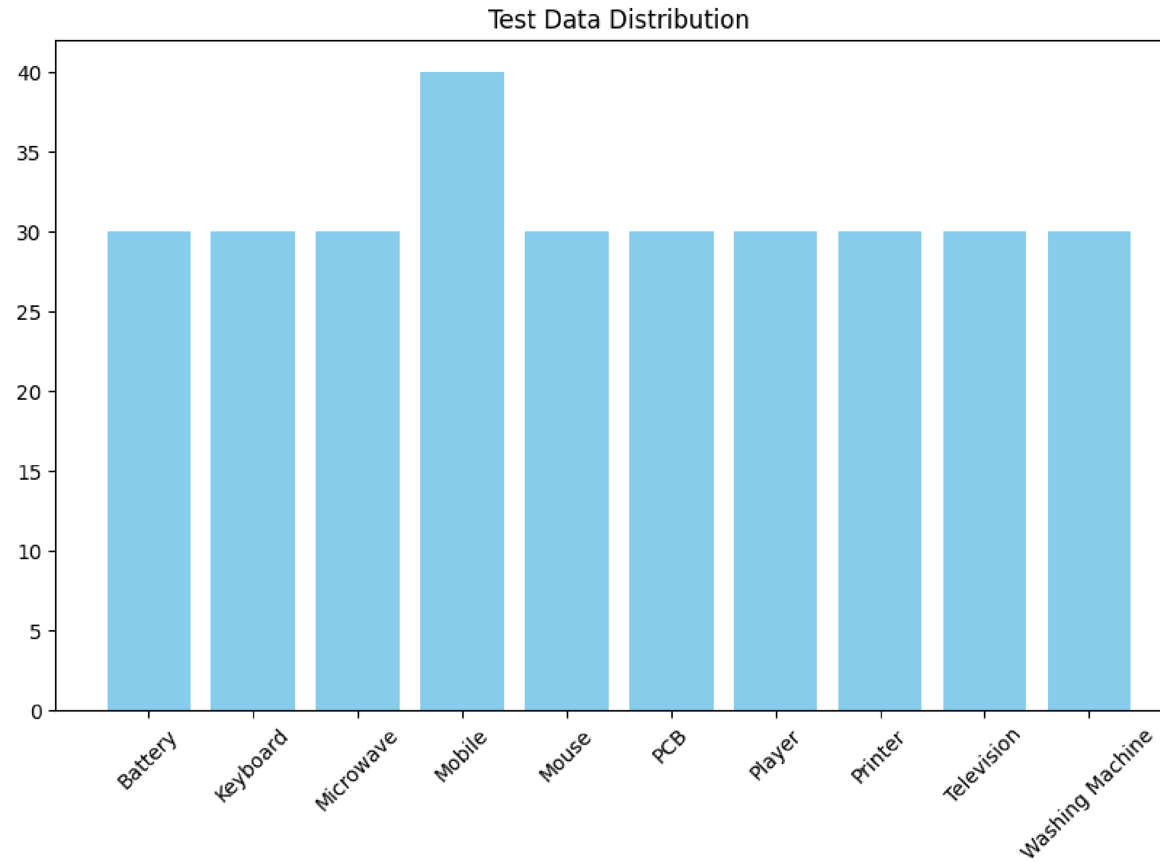
In [5]:

```
# Plot class distribution
def plot_class_distribution(dataset, title):
    counts = {}
    for _, labels in dataset:
        for label in labels.numpy():
            class_name = dataset.class_names[label]
            counts[class_name] = counts.get(class_name, 0) + 1
    plt.figure(figsize=(10,6))
    plt.bar(counts.keys(), counts.values(), color='skyblue')
    plt.title(title)
    plt.xticks(rotation=45)
```

```
    plt.show()

plot_class_distribution(datatrain, "Training Data Distribution")
plot_class_distribution(datavalid, "Validation Data Distribution")
plot_class_distribution(datatest, "Test Data Distribution")
```







DATA PREPROCESSING

In [6]:

```
# DATA PREPROCESSING / PREPARATION
data_augmentation = tf.keras.Sequential([
    layers.RandomFlip("horizontal"),
    layers.RandomRotation(0.1),
    layers.RandomZoom(0.1),
])

datatrain = datatrain.prefetch(tf.data.AUTOTUNE)
datavalid = datavalid.prefetch(tf.data.AUTOTUNE)
datatest  = datatest.prefetch(tf.data.AUTOTUNE)
```

MODEL SELECTION USING EFFICIENTNET

In [7]:

```
# MODEL SELECTION
base_model = EfficientNetV2B0(input_shape=IMG_SIZE+(3,), include_top=False, wei
for layer in base_model.layers[:100]:
    layer.trainable = False

inputs = layers.Input(shape=IMG_SIZE+(3,))
x = data_augmentation(inputs)
x = preprocess_input(x)
x = base_model(x, training=False)
```

```
x = layers.GlobalAveragePooling2D()(x)
x = layers.Dropout(0.2)(x)
outputs = layers.Dense(10, activation='softmax')(x)
model = models.Model(inputs, outputs)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-application
s/efficientnet_v2/efficientnetv2-b0_notop.h5
24274472/24274472 ━━━━━━━━━━━━━━━━━━━━ 0s 0us/step
```

MODEL TRAINING

In [9]:

```
# MODEL TRAINING
from tensorflow.keras.callbacks import EarlyStopping, ReduceLROnPlateau
model.compile(optimizer=tf.keras.optimizers.Adam(1e-4),
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

early_stop = EarlyStopping(monitor='val_loss', patience=3, restore_best_weights=
reduce_lr = ReduceLROnPlateau(monitor='val_loss', factor=0.5, patience=2)

history = model.fit(datatrain, validation_data=datavalid, epochs=15, callbacks=
```

```
Epoch 1/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 52s 180ms/step - accuracy: 0.2598 - loss: 2.1305 - val_
accuracy: 0.7967 - val_loss: 1.1384 - learning_rate: 1.0000e-04
Epoch 2/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 10s 137ms/step - accuracy: 0.7977 - loss: 0.9845 - val_
accuracy: 0.9033 - val_loss: 0.5048 - learning_rate: 1.0000e-04
Epoch 3/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 20s 123ms/step - accuracy: 0.8681 - loss: 0.4941 - val_
accuracy: 0.9333 - val_loss: 0.3257 - learning_rate: 1.0000e-04
Epoch 4/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 11s 140ms/step - accuracy: 0.9202 - loss: 0.3001 - val_
accuracy: 0.9300 - val_loss: 0.2432 - learning_rate: 1.0000e-04
Epoch 5/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 20s 130ms/step - accuracy: 0.9412 - loss: 0.2134 - val_
accuracy: 0.9500 - val_loss: 0.1960 - learning_rate: 1.0000e-04
Epoch 6/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 10s 125ms/step - accuracy: 0.9487 - loss: 0.1866 - val_
accuracy: 0.9433 - val_loss: 0.1804 - learning_rate: 1.0000e-04
Epoch 7/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 10s 123ms/step - accuracy: 0.9540 - loss: 0.1712 - val_
accuracy: 0.9533 - val_loss: 0.1624 - learning_rate: 1.0000e-04
Epoch 8/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 11s 142ms/step - accuracy: 0.9671 - loss: 0.1273 - val_
accuracy: 0.9500 - val_loss: 0.1550 - learning_rate: 1.0000e-04
Epoch 9/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 19s 123ms/step - accuracy: 0.9703 - loss: 0.1106 - val_
accuracy: 0.9500 - val_loss: 0.1546 - learning_rate: 1.0000e-04
Epoch 10/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 9s 121ms/step - accuracy: 0.9827 - loss: 0.0785 - val_a
ccuracy: 0.9567 - val_loss: 0.1511 - learning_rate: 1.0000e-04
Epoch 11/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 11s 134ms/step - accuracy: 0.9785 - loss: 0.0719 - val_
```

```
76/76 ━━━━━━━━━━━━━━━━━━━━ 11s 134ms/step - accuracy: 0.9783 - loss: 0.0719 - val_
accuracy: 0.9600 - val_loss: 0.1248 - learning_rate: 1.0000e-04
Epoch 12/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 10s 133ms/step - accuracy: 0.9772 - loss: 0.0771 - val_
accuracy: 0.9567 - val_loss: 0.1306 - learning_rate: 1.0000e-04
Epoch 13/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 10s 131ms/step - accuracy: 0.9863 - loss: 0.0611 - val_
accuracy: 0.9633 - val_loss: 0.1198 - learning_rate: 1.0000e-04
Epoch 14/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 10s 123ms/step - accuracy: 0.9917 - loss: 0.0386 - val_
accuracy: 0.9600 - val_loss: 0.1251 - learning_rate: 1.0000e-04
Epoch 15/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 11s 142ms/step - accuracy: 0.9923 - loss: 0.0323 - val_
accuracy: 0.9700 - val_loss: 0.1191 - learning_rate: 1.0000e-04
```

MODEL TUNING AND OPTIMIZATION

In [10]:

```
# MODEL TUNING AND OPTIMIZATION (optional fine-tune)
for layer in base_model.layers[100:]:
    layer.trainable = True
model.compile(optimizer=tf.keras.optimizers.Adam(1e-5),
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])
model.fit(datatrain, validation_data=datavalid, epochs=5, callbacks=[early_stop
```

```
Epoch 1/5
76/76 ━━━━━━━━━━━━━━━━━━━━ 47s 181ms/step - accuracy: 0.9923 - loss: 0.0303 - val_
accuracy: 0.9633 - val_loss: 0.1201 - learning_rate: 1.0000e-05
Epoch 2/5
76/76 ━━━━━━━━━━━━━━━━━━━━ 10s 134ms/step - accuracy: 0.9875 - loss: 0.0374 - val_
accuracy: 0.9633 - val_loss: 0.1144 - learning_rate: 1.0000e-05
Epoch 3/5
76/76 ━━━━━━━━━━━━━━━━━━━━ 11s 138ms/step - accuracy: 0.9941 - loss: 0.0353 - val_
accuracy: 0.9633 - val_loss: 0.1188 - learning_rate: 1.0000e-05
Epoch 4/5
76/76 ━━━━━━━━━━━━━━━━━━━━ 19s 121ms/step - accuracy: 0.9895 - loss: 0.0435 - val_
accuracy: 0.9633 - val_loss: 0.1256 - learning_rate: 1.0000e-05
Epoch 5/5
76/76 ━━━━━━━━━━━━━━━━━━━━ 11s 135ms/step - accuracy: 0.9950 - loss: 0.0286 - val_
accuracy: 0.9700 - val_loss: 0.1140 - learning_rate: 5.0000e-06
```

Out[10]:

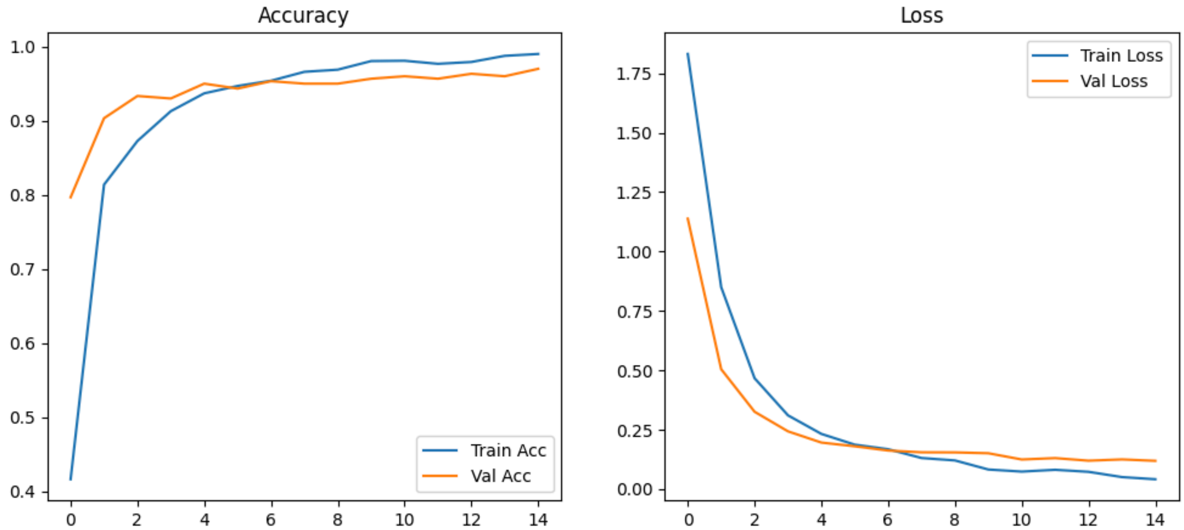
```
<keras.src.callbacks.history.History at 0x7d08ecd52850>
```

MODEL PERFORMANCE VISUALIZATION

In [11]:

```
# MODEL PERFORMANCE VISUALIZATION
plt.figure(figsize=(12,5))
plt.subplot(1,2,1)
plt.plot(history.history['accuracy'], label='Train Acc')
plt.plot(history.history['val_accuracy'], label='Val Acc')
plt.title('Accuracy')
plt.legend()
plt.subplot(1,2,2)
plt.plot(history.history['loss'], label='Train Loss')
```

```
plt.plot(history.history['loss'], label='Train Loss')
plt.plot(history.history['val_loss'], label='Val Loss')
plt.title('Loss')
plt.legend()
plt.show()
```



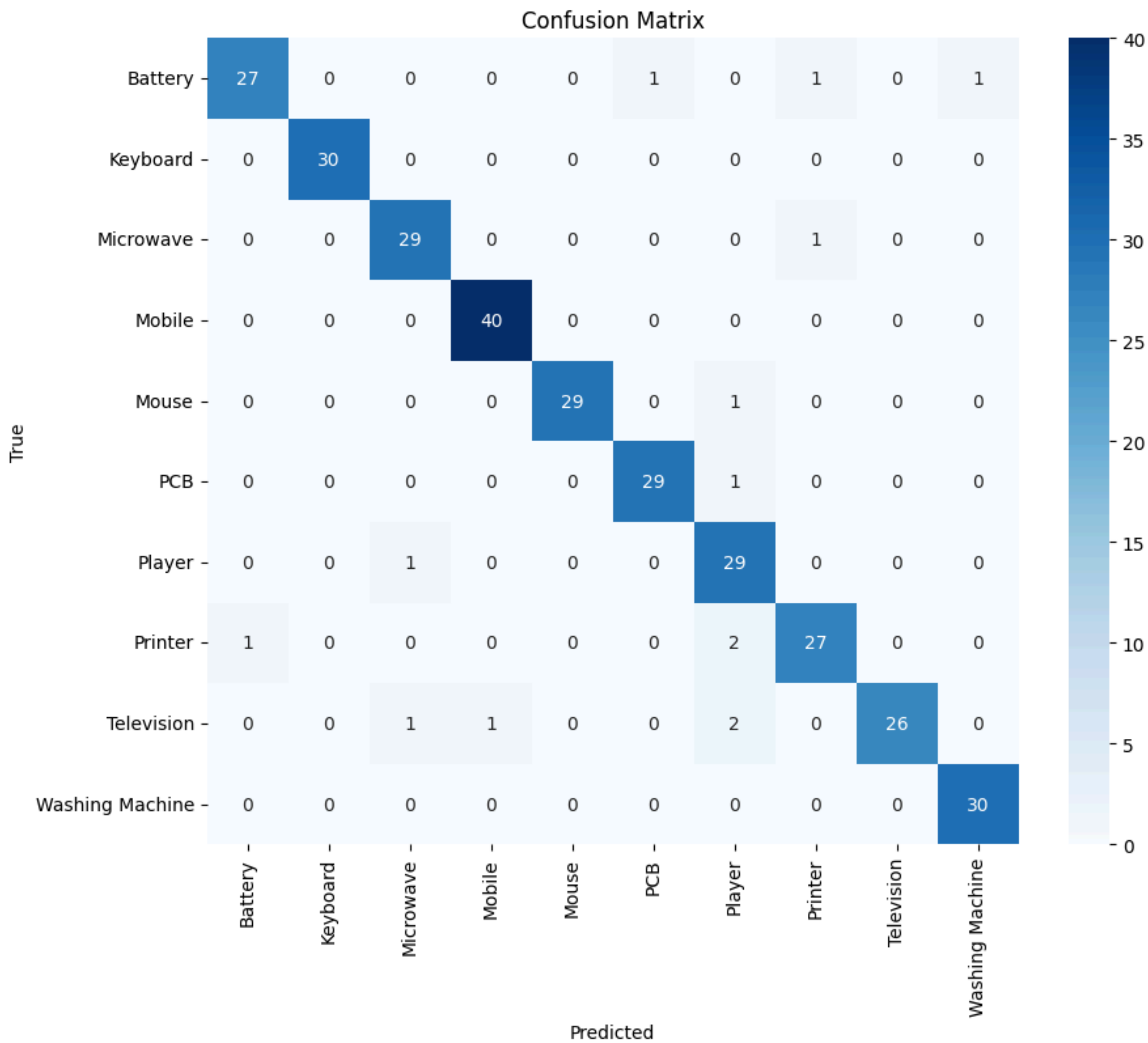
MODEL EVALUATION AND CONFUSION MATRIX

In [12]:

```
#  MODEL EVALUATION
test_loss, test_acc = model.evaluate(datatest)
print(f"Test Accuracy: {test_acc:.4f}, Test Loss: {test_loss:.4f}")

y_true = np.concatenate([y.numpy() for _, y in datatest], axis=0)
y_pred = np.argmax(model.predict(datatest), axis=1)

cm = confusion_matrix(y_true, y_pred)
print(classification_report(y_true, y_pred, target_names=class_names))

plt.figure(figsize=(10,8))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues', xticklabels=class_names, ytic
plt.xlabel("Predicted")
plt.ylabel("True")
plt.title("Confusion Matrix")
plt.show()
```

```
10/10 ━━━━━━━━━━━━━━━━━━━━ 1s 128ms/step - accuracy: 0.9555 - loss: 0.1602
✅ Test Accuracy: 0.9548, Test Loss: 0.1317
10/10 ━━━━━━━━━━━━━━━━━━━━ 7s 393ms/step
              precision    recall  f1-score   support

     Battery       0.96      0.90      0.93        30
    Keyboard       1.00      1.00      1.00        30
   Microwave       0.94      0.97      0.95        30
      Mobile       0.98      1.00      0.99        40
       Mouse       1.00      0.97      0.98        30
```

```
          Mouse       1.00      0.97      0.98        30
            PCB       0.97      0.97      0.97        30
         Player       0.83      0.97      0.89        30
        Printer       0.93      0.90      0.92        30
     Television       1.00      0.87      0.93        30
Washing Machine       0.97      1.00      0.98        30

       accuracy                           0.95       310
      macro avg       0.96      0.95      0.95       310
   weighted avg       0.96      0.95      0.95       310
```



FINAL TESTING AND SAVE THE MODEL

In [18]:

```
# FINAL TESTING AND SAVE THE MODEL
model.save('efficientnetv2b0_ewaste_final.keras')
print("Keras model saved")
```

```
Keras model saved
```

Save TFLite

In [19]:

```python
# Save TFLite
converter = tf.lite.TFLiteConverter.from_keras_model(model)
converter.optimizations = [tf.lite.Optimize.DEFAULT]
tflite_model = converter.convert()
with open('efficientnetv2b0_ewaste_final.tflite', 'wb') as f:
    f.write(tflite_model)
print("TFLite model saved")
```

```
Saved artifact at '/tmp/tmpodr7su2v'. The following endpoints are available:

* Endpoint 'serve'
  args_0 (POSITIONAL_ONLY): TensorSpec(shape=(None, 128, 128, 3), dtype=tf.float3
2, name='keras_tensor_270')
Output Type:
  TensorSpec(shape=(None, 10), dtype=tf.float32, name=None)
Captures:
  137479627293328: TensorSpec(shape=(1, 1, 1, 3), dtype=tf.float32, name=None)
  137479627293136: TensorSpec(shape=(1, 1, 1, 3), dtype=tf.float32, name=None)
  137480611166160: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627293712: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627296208: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627295824: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627295440: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627296016: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627297360: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627298320: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627297552: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627296784: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627297744: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627301008: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627300048: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627300432: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627300240: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627298128: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627302928: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627303888: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627303120: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627299472: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627304848: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627303312: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627305616: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627304080: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627302160: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627307152: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627306768: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627308112: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627307344: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627305232: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627304464: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627620816: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627621776: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627308304: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627620624: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627622736: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627622352: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627623696: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627622928: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627621584: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627621008: TensorSpec(shape=(), dtype=tf.resource, name=None)
  137479627624848: TensorSpec(shape=(), dtype=tf.resource, name=None)
```

```
137479627625808: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627625040: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627623504: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627624272: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627626960: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627627920: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627627152: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627625616: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627627344: TensorSpec(shape=(), dtype=tf.resource, name=None)
137480611162704: TensorSpec(shape=(), dtype=tf.resource, name=None)
137480611164432: TensorSpec(shape=(), dtype=tf.resource, name=None)
137480611166352: TensorSpec(shape=(), dtype=tf.resource, name=None)
137480611164816: TensorSpec(shape=(), dtype=tf.resource, name=None)
137480611165008: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627629456: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627630224: TensorSpec(shape=(), dtype=tf.resource, name=None)
137480611165776: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627626384: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627628112: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627631184: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627629648: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627631568: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627630416: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627632720: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627633488: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627632336: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627632144: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627634448: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627634064: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627635408: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627634640: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627631376: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627636368: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627635984: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628030032: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627634832: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479627632912: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628031568: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628031760: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628031184: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628032144: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628030992: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628033296: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628034064: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628032912: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628032720: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628033488: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628035408: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628036368: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628035600: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628034256: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628037328: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628036944: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628038288: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628037520: TensorSpec(shape=(), dtype=tf.resource, name=None)
137479628035216: TensorSpec(shape=(), dtype=tf.resource, name=None)
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TFLite model saved
```

Predictions on sample test images

In [15]:

```
# Show predictions on sample test images
for images, labels in datatest.take(1):
    preds = model.predict(images)
    pred_classes = tf.argmax(preds, axis=1)
    for i in range(8):
        plt.imshow(images[i].numpy().astype("uint8"))
        plt.title(f"True: {class_names[labels[i]]}, Pred: {class_names[pred_cla
        plt.axis("off")
        plt.show()
```

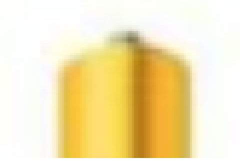
```
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
```

True: Battery, Pred: Battery

True: Battery, Pred: Printer

True: Battery, Pred: Battery

True: Battery, Pred: Battery



True: Battery, Pred: Battery

True: Battery, Pred: Battery

True: Battery, Pred: PCB

True: Battery, Pred: Battery

Using CNN Model

In [16]:

```
# Normal CNN Model
normal_model = tf.keras.Sequential([
    tf.keras.layers.Rescaling(1./255, input_shape=IMG_SIZE+(3,)),  # Simple resc
    tf.keras.layers.Conv2D(32, 3, activation='relu'),
    tf.keras.layers.MaxPooling2D(),
    tf.keras.layers.Conv2D(64, 3, activation='relu'),
    tf.keras.layers.MaxPooling2D(),
    tf.keras.layers.Conv2D(128, 3, activation='relu'),
    tf.keras.layers.GlobalAveragePooling2D(),
    tf.keras.layers.Dropout(0.2),
    tf.keras.layers.Dense(10, activation='softmax')
])

normal_model.compile(optimizer='adam',
                    loss='sparse_categorical_crossentropy',
                    metrics=['accuracy'])
normal_history = normal_model.fit(datatrain,
                                  validation_data=datavalid,
                                  epochs=15,
                                  callbacks=[early_stop, reduce_lr])
```

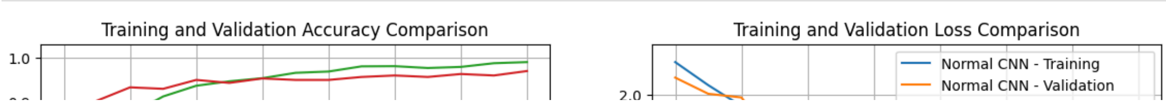
```
Epoch 1/15
/usr/local/lib/python3.11/dist-packages/keras/src/layers/preprocessing/tf_data_lay
er.py:19: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as the firs
t layer in the model instead.
  super().__init__(**kwargs)
76/76 ━━━━━━━━━━━━━━━━━━━━ 13s 126ms/step - accuracy: 0.1479 - loss: 2.2522 - val_
accuracy: 0.2133 - val_loss: 2.1031 - learning_rate: 0.0010
Epoch 2/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 6s 79ms/step - accuracy: 0.2411 - loss: 2.0616 - val_ac
curacy: 0.2833 - val_loss: 2.0063 - learning_rate: 0.0010
Epoch 3/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 11s 87ms/step - accuracy: 0.3085 - loss: 1.9544 - val_a
ccuracy: 0.2500 - val_loss: 1.9843 - learning_rate: 0.0010
Epoch 4/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 10s 84ms/step - accuracy: 0.3229 - loss: 1.8475 - val_a
ccuracy: 0.3400 - val_loss: 1.7361 - learning_rate: 0.0010
Epoch 5/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 11s 96ms/step - accuracy: 0.3549 - loss: 1.7743 - val_a
ccuracy: 0.4300 - val_loss: 1.6915 - learning_rate: 0.0010
Epoch 6/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 6s 79ms/step - accuracy: 0.3797 - loss: 1.7258 - val_ac
curacy: 0.4267 - val_loss: 1.6392 - learning_rate: 0.0010
Epoch 7/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 7s 96ms/step - accuracy: 0.4125 - loss: 1.6638 - val_ac
curacy: 0.4700 - val_loss: 1.6006 - learning_rate: 0.0010
Epoch 8/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 9s 82ms/step - accuracy: 0.4091 - loss: 1.6414 - val_ac
curacy: 0.4433 - val_loss: 1.6227 - learning_rate: 0.0010
Epoch 9/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 11s 91ms/step - accuracy: 0.4209 - loss: 1.6662 - val_a
```

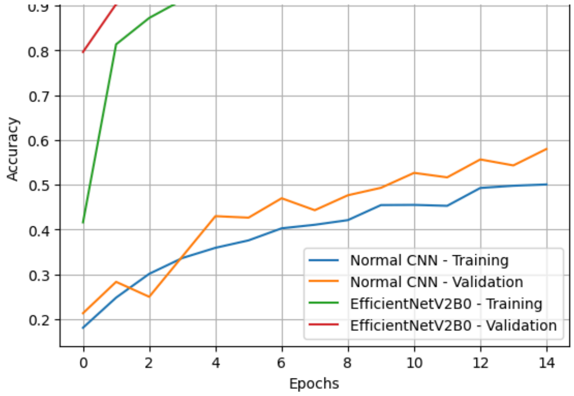
```
ccuracy: 0.4767 - val_loss: 1.4897 - learning_rate: 0.0010
Epoch 10/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 10s 91ms/step - accuracy: 0.4577 - loss: 1.5337 - val_a
ccuracy: 0.4933 - val_loss: 1.4748 - learning_rate: 0.0010
Epoch 11/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 7s 98ms/step - accuracy: 0.4625 - loss: 1.4887 - val_ac
curacy: 0.5267 - val_loss: 1.4806 - learning_rate: 0.0010
Epoch 12/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 6s 83ms/step - accuracy: 0.4660 - loss: 1.4985 - val_ac
curacy: 0.5167 - val_loss: 1.4915 - learning_rate: 0.0010
Epoch 13/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 11s 89ms/step - accuracy: 0.4701 - loss: 1.4690 - val_a
ccuracy: 0.5567 - val_loss: 1.3467 - learning_rate: 5.0000e-04
Epoch 14/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 11s 95ms/step - accuracy: 0.5041 - loss: 1.3938 - val_a
ccuracy: 0.5433 - val_loss: 1.3434 - learning_rate: 5.0000e-04
Epoch 15/15
76/76 ━━━━━━━━━━━━━━━━━━━━ 6s 81ms/step - accuracy: 0.5215 - loss: 1.3725 - val_ac
curacy: 0.5800 - val_loss: 1.2799 - learning_rate: 5.0000e-04
```

Plot between CNN and EfficientNet

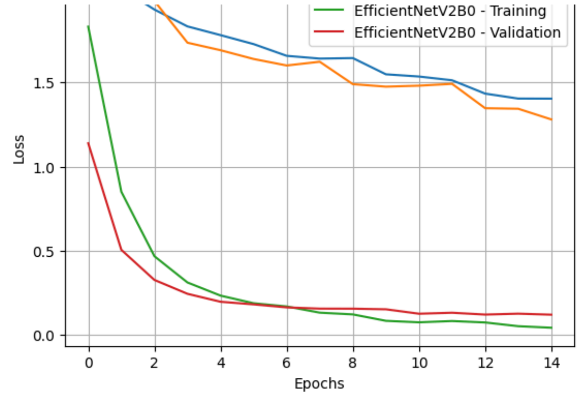
In [17]:

```python
import matplotlib.pyplot as plt

plt.figure(figsize=(14, 5))

# Accuracy Comparison
plt.subplot(1, 2, 1)
plt.plot(normal_history.history['accuracy'], label='Normal CNN - Training')
plt.plot(normal_history.history['val_accuracy'], label='Normal CNN - Validation
plt.plot(history.history['accuracy'], label='EfficientNetV2B0 - Training')
plt.plot(history.history['val_accuracy'], label='EfficientNetV2B0 - Validation'
plt.title('Training and Validation Accuracy Comparison')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.grid(True)

# Loss Comparison
plt.subplot(1, 2, 2)
plt.plot(normal_history.history['loss'], label='Normal CNN - Training')
plt.plot(normal_history.history['val_loss'], label='Normal CNN - Validation')
plt.plot(history.history['loss'], label='EfficientNetV2B0 - Training')
plt.plot(history.history['val_loss'], label='EfficientNetV2B0 - Validation')
plt.title('Training and Validation Loss Comparison')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.grid(True)

plt.show()
```





Accuracy
Epochs
Normal CNN - Training
Normal CNN - Validation
EfficientNetV2B0 - Training
EfficientNetV2B0 - Validation



Loss
Epochs
EfficientNetV2B0 - Training
EfficientNetV2B0 - Validation