Lab Assignment No.: 7 Feature Engineering

Apply Preprocessing steps/ Feature Engineering like handling missing values, transformations etc on the given dataset. Write your observation in conclusion

Theory

All machine learning algorithms use some input data to generate outputs. Input data contains many features which may not be in proper form to be given to the model directly. It needs some kind of processing and here feature engineering helps. Feature engineering fulfils mainly two goals:

It prepares the input dataset in the form which is required for a specific model or machine learning algorithm. Feature engineering helps in improving the performance of machine learning models magically.

The main feature engineering techniques are:

1. Missing data imputation
2. Categorical encoding
3. Variable transformation
4. Outlier engineering
5. Date and time engineering

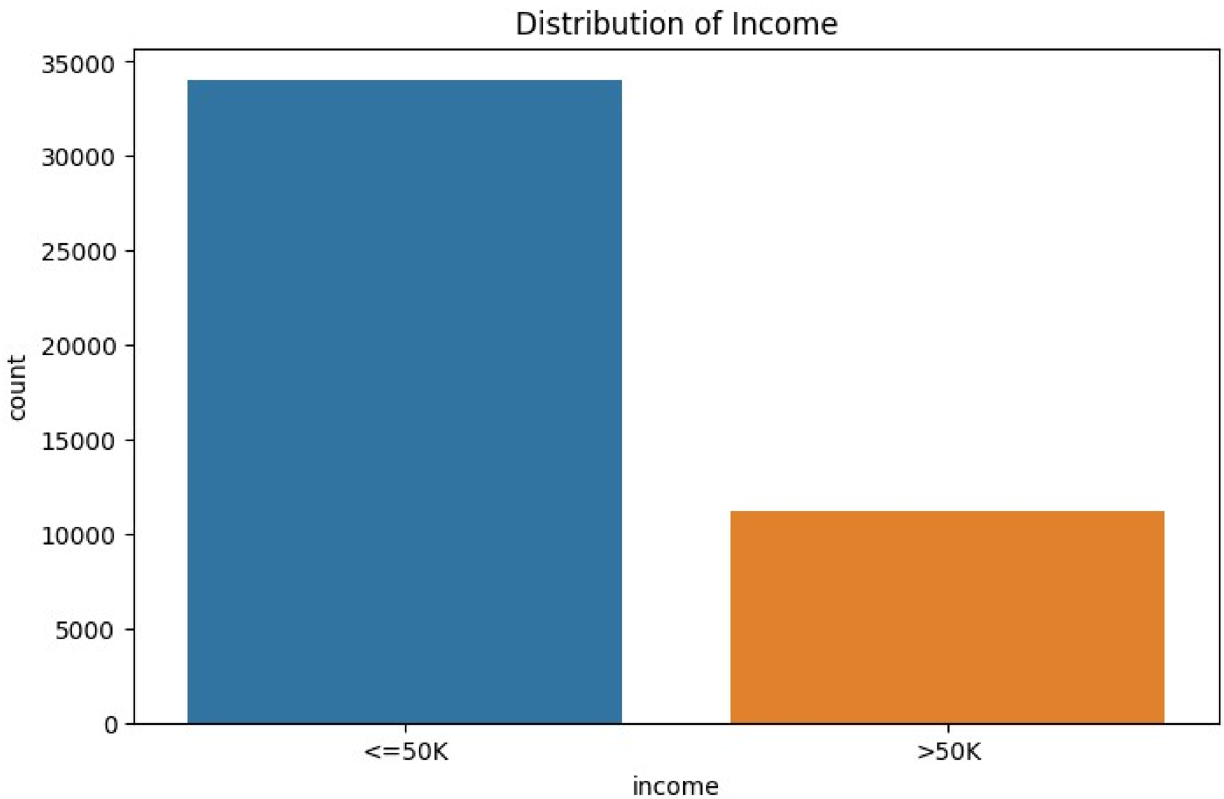
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import scipy.stats as stats
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split

df = pd.read_csv("adult.csv")

df.head()
```

```
   age  workclass  fnlwgt     education  educational-num      marital-
status  \
0   25    Private  226802          11th                7        Never-
married
1   38    Private   89814       HS-grad                9  Married-civ-
spouse
2   28  Local-gov  336951    Assoc-acdm               12  Married-civ-
spouse
3   44    Private  160323  Some-college               10  Married-civ-
spouse
4   18          ?  103497  Some-college               10        Never-
```

```
married

           occupation relationship   race  gender  capital-gain
capital-loss  \
0  Machine-op-inspct    Own-child  Black    Male             0
0
1    Farming-fishing      Husband  White    Male             0
0
2    Protective-serv      Husband  White    Male             0
0
3  Machine-op-inspct      Husband  Black    Male          7688
0
4                  ?    Own-child  White  Female             0
0

   hours-per-week native-country income
0              40  United-States  <=50K
1              50  United-States  <=50K
2              40  United-States   >50K
3              40  United-States   >50K
4              30  United-States  <=50K

df = df.replace('?', pd.NA)
df = df.dropna()
```

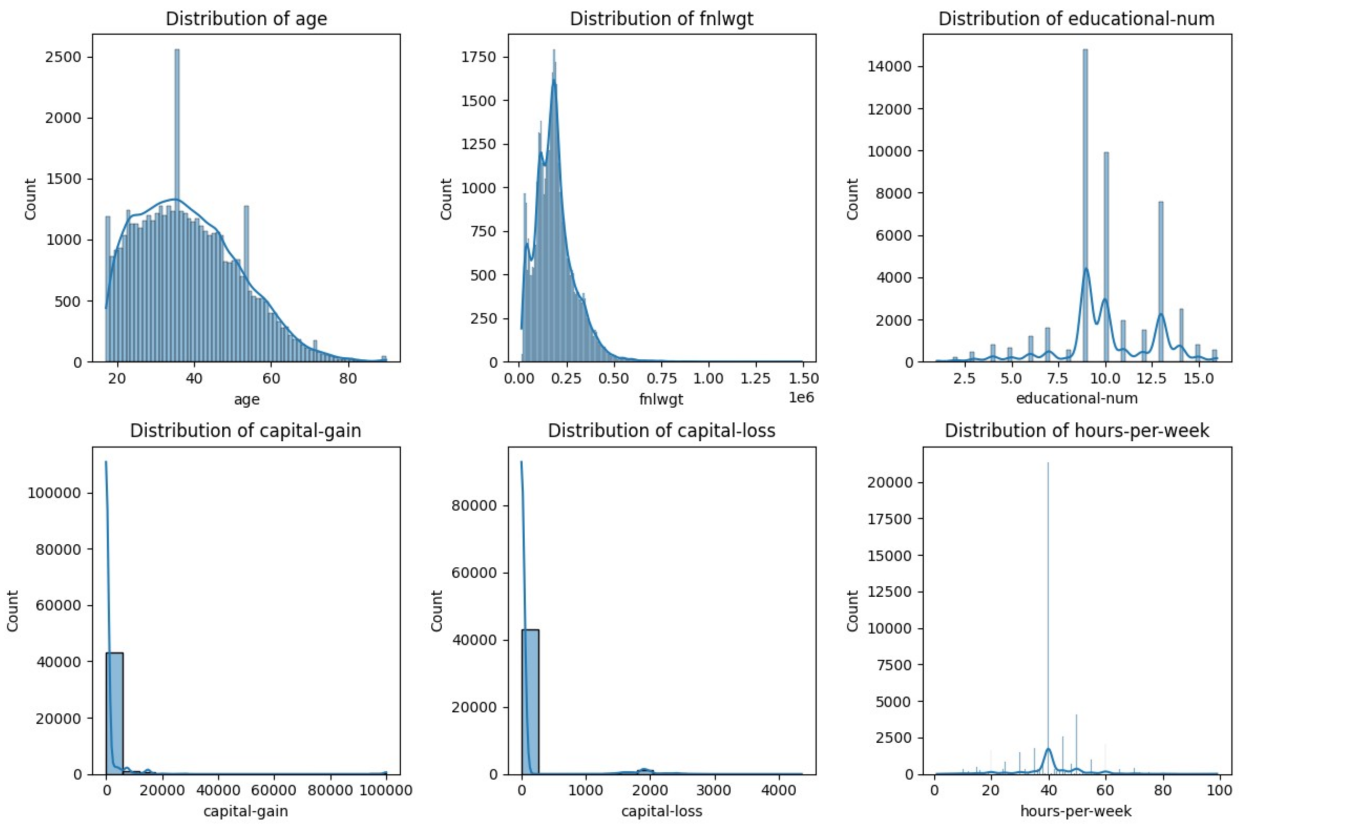
Distribution of Target Variable

```
plt.figure(figsize=(8, 5))
sns.countplot(data=df, x='income')
plt.title("Distribution of Income")
plt.show()
```



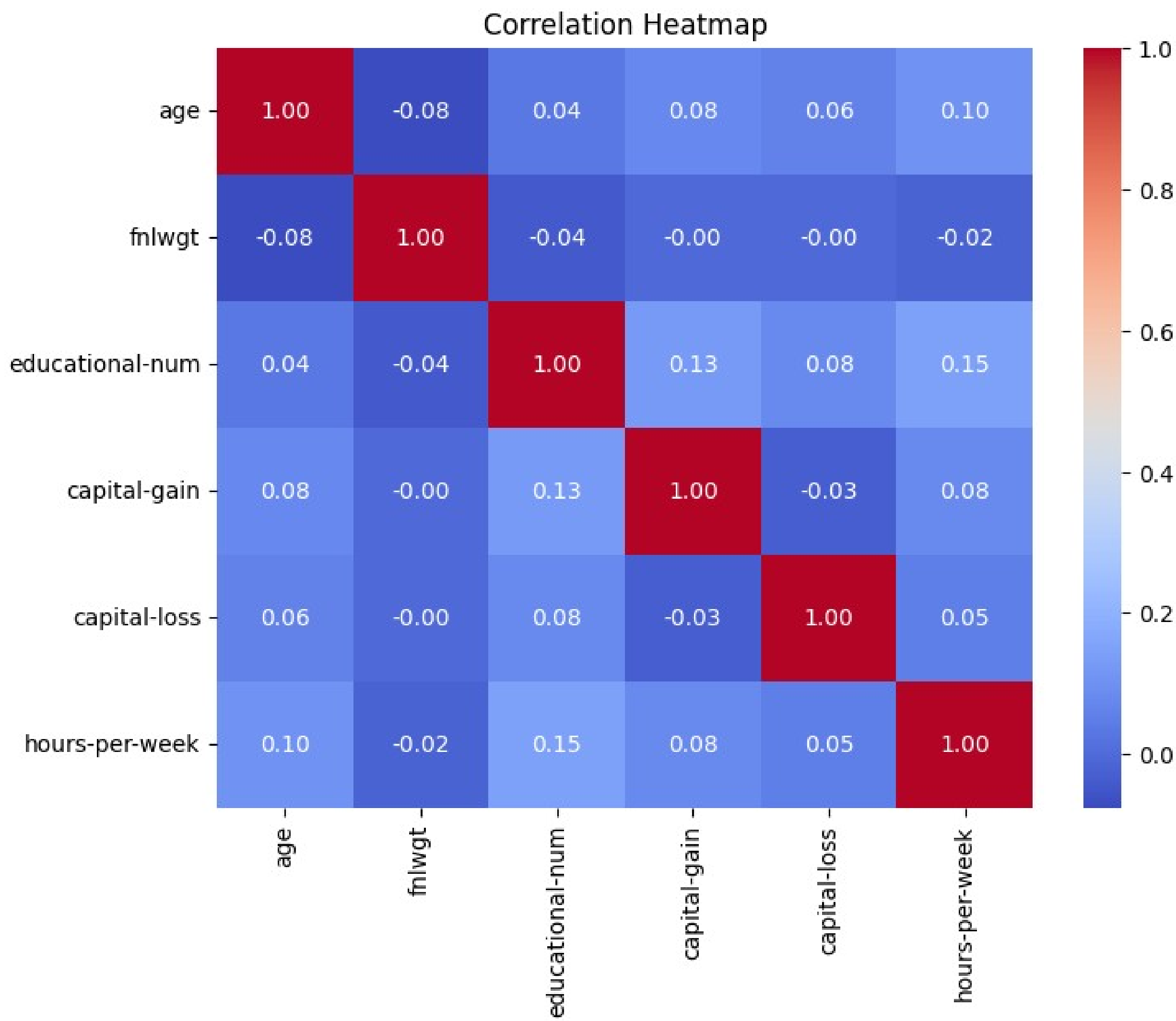
Distribution of Numeric Features

```
numeric_features = ['age', 'fnlwgt', 'educational-num', 'capital-
gain', 'capital-loss', 'hours-per-week']

plt.figure(figsize=(12, 8))
for i, feature in enumerate(numeric_features, 1):
    plt.subplot(2, 3, i)
    sns.histplot(df[feature], kde=True)
    plt.title(f'Distribution of {feature}')
plt.tight_layout()
plt.show()
```




```
categorical_features = ['workclass', 'education', 'marital-status',
'occupation', 'relationship', 'race', 'gender', 'native-country']

plt.figure(figsize=(16, 18))
for i, feature in enumerate(categorical_features, 1):
    plt.subplot(4, 2, i)
    sns.countplot(data=df, x=feature, hue='income')
    plt.title(f'{feature} vs. Income')
    plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
```


```
correlation_matrix = df[numeric_features].corr()
plt.figure(figsize=(8, 6))
sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm',
fmt=".2f")
plt.title("Correlation Heatmap")
plt.show()
```



Feature Engineering

```
#Example 1: Binning Age

age_bins = [0, 25, 45, 65, 100]
age_labels = ['Young', 'Middle-Aged', 'Senior', 'Elderly']
df['Age_Category'] = pd.cut(df['age'], bins=age_bins,
labels=age_labels)

# Example 2: Education Level Mapping

education_mapping = {
    'Preschool': 1, '1st-4th': 2, '5th-6th': 3, '7th-8th': 4, '9th':
5,
    '10th': 6, '11th': 7, '12th': 8, 'HS-grad': 9, 'Some-college': 10,
    'Assoc-acdm': 11, 'Assoc-voc': 12, 'Bachelors': 13, 'Masters': 14,
'Doctorate': 15
```

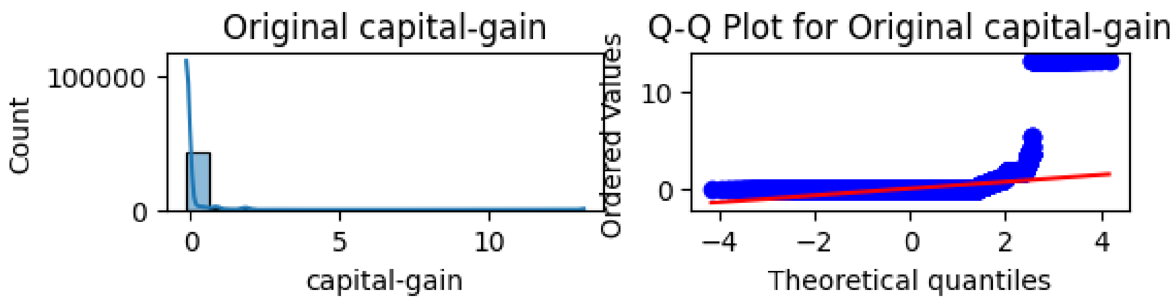
```
}
df['Education_Level'] = df['education'].map(education_mapping)

# Example 3: One-Hot Encoding for Categorical Features

df = pd.get_dummies(df, columns=categorical_features, drop_first=True)

# Example 4: Scaling Numeric Features

scaler = StandardScaler()
numeric_features += ['Education_Level']
df[numeric_features] = scaler.fit_transform(df[numeric_features])

# Example 5: Encoding Income as 0 and 1

df['income'] = df['income'].map({'<=50K': 0, '>50K': 1})
df.head()
```

```
        age    fnlwgt  educational-num  capital-gain  capital-loss  \
0 -1.024983  0.350889        -1.221559     -0.146733      -0.21878
1 -0.041455 -0.945878        -0.438122     -0.146733      -0.21878
2 -0.798015  1.393592         0.737034     -0.146733      -0.21878
3  0.412481 -0.278420        -0.046403      0.877467      -0.21878
5 -0.344079  0.084802        -1.613277     -0.146733      -0.21878

   hours-per-week  income Age_Category  Education_Level  
workclass_Local-gov  \
0       -0.078120       0        Young        -1.226897
0
1        0.754701       0  Middle-Aged        -0.417105
0
2       -0.078120       1  Middle-Aged         0.392686
1
3       -0.078120       1  Middle-Aged        -0.012210
0
5       -0.910942       0  Middle-Aged        -1.631793
0

   ...  native-country_Portugal  native-country_Puerto-Rico  \
0  ...                        0                           0
1  ...                        0                           0
2  ...                        0                           0
3  ...                        0                           0
5  ...                        0                           0

   native-country_Scotland  native-country_South  native-
country_Taiwan  \
0                        0                     0
0
1                        0                     0
0
```

```
2                          0                        0
0
3                          0                        0
0
5                          0                        0
0

   native-country_Thailand  native-country_Trinadad&Tobago  \
0                        0                               0
1                        0                               0
2                        0                               0
3                        0                               0
5                        0                               0

   native-country_United-States  native-country_Vietnam  \
0                             1                       0
1                             1                       0
2                             1                       0
3                             1                       0
5                             1                       0

   native-country_Yugoslavia
0                          0
1                          0
2                          0
3                          0
5                          0

[5 rows x 99 columns]
```

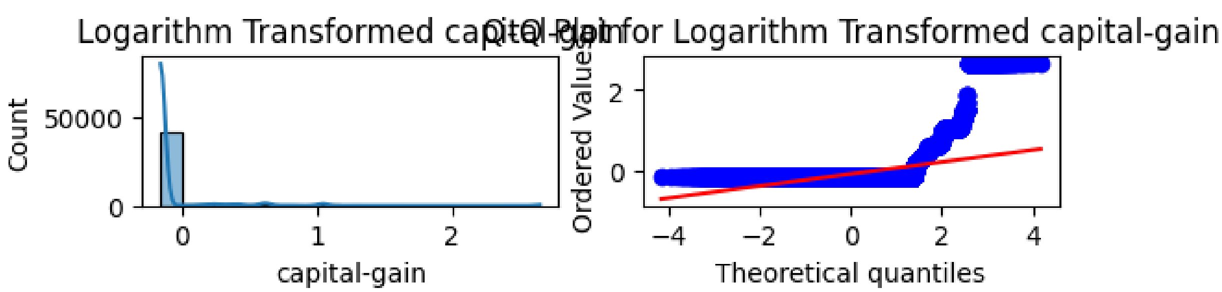
Variable Transformations

```
numeric_feature = 'capital-gain'
plt.figure(figsize=(12, 24))

<Figure size 1200x2400 with 0 Axes>

<Figure size 1200x2400 with 0 Axes>

plt.subplot(4, 2, 1)
sns.histplot(df[numeric_feature], kde=True)
plt.title(f'Original {numeric_feature}')

plt.subplot(4, 2, 2)
stats.probplot(df[numeric_feature], dist="norm", plot=plt)
plt.title(f'Q-Q Plot for Original {numeric_feature}')

Text(0.5, 1.0, 'Q-Q Plot for Original capital-gain')
```




```
log_transformed = np.log(df[numeric_feature] + 1)
plt.subplot(4, 2, 3)
sns.histplot(log_transformed, kde=True)
plt.title(f'Logarithm Transformed {numeric_feature}')


plt.subplot(4, 2, 4)
stats.probplot(log_transformed, dist="norm", plot=plt)
# plt.title(f'Q-Q Plot for Logarithm Transformed {numeric_feature}')
```

```
Text(0.5, 1.0, 'Q-Q Plot for Logarithm Transformed capital-gain')
```

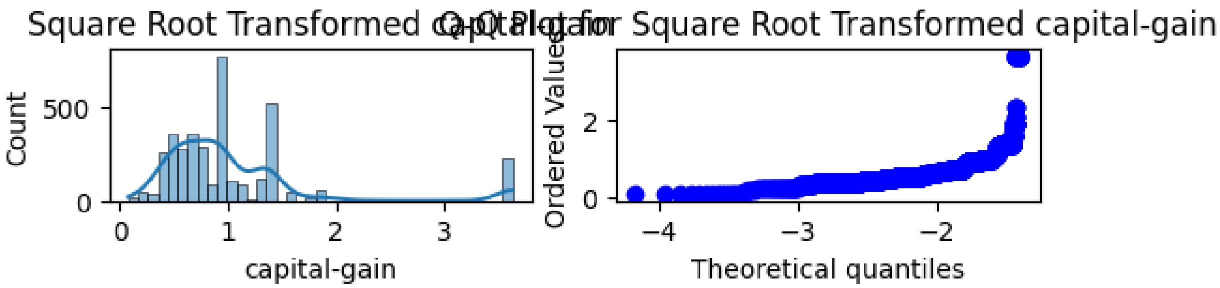



```
# Square root transformation

sqrt_transformed = np.sqrt(df[numeric_feature])
```

```
c:\Users\UMAP\anaconda3\lib\site-packages\pandas\core\
arraylike.py:397: RuntimeWarning: invalid value encountered in sqrt
  result = getattr(ufunc, method)(*inputs, **kwargs)
```

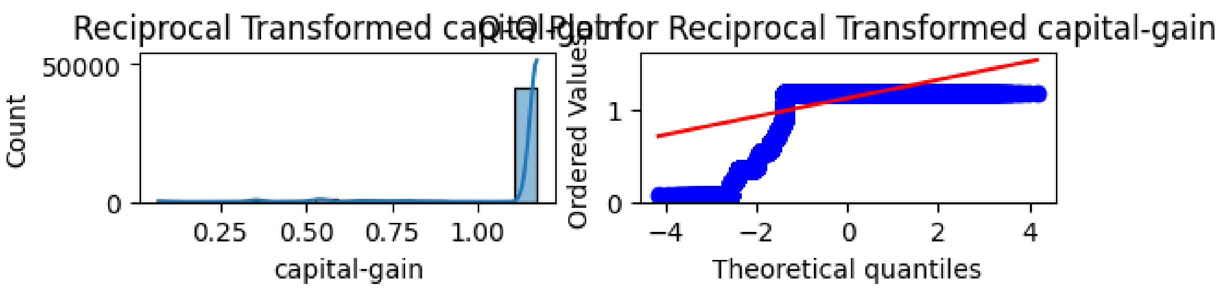
```
plt.subplot(4, 2, 5)
sns.histplot(sqrt_transformed, kde=True)
plt.title(f'Square Root Transformed {numeric_feature}')

plt.subplot(4, 2, 6)
stats.probplot(sqrt_transformed, dist="norm", plot=plt)
plt.title(f'Q-Q Plot for Square Root Transformed {numeric_feature}')
```

```
Text(0.5, 1.0, 'Q-Q Plot for Square Root Transformed capital-gain')
```



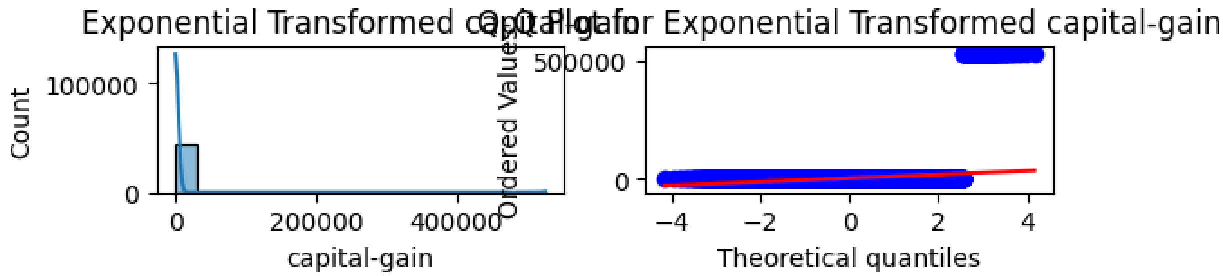

```
reciprocal_transformed = 1 / (df[numeric_feature] + 1)
plt.subplot(4, 2, 7)
sns.histplot(reciprocal_transformed, kde=True)
plt.title(f'Reciprocal Transformed {numeric_feature}')

plt.subplot(4, 2, 8)
stats.probplot(reciprocal_transformed, dist="norm", plot=plt)
plt.title(f'Q-Q Plot for Reciprocal Transformed {numeric_feature}')
```

```
Text(0.5, 1.0, 'Q-Q Plot for Reciprocal Transformed capital-gain')
```

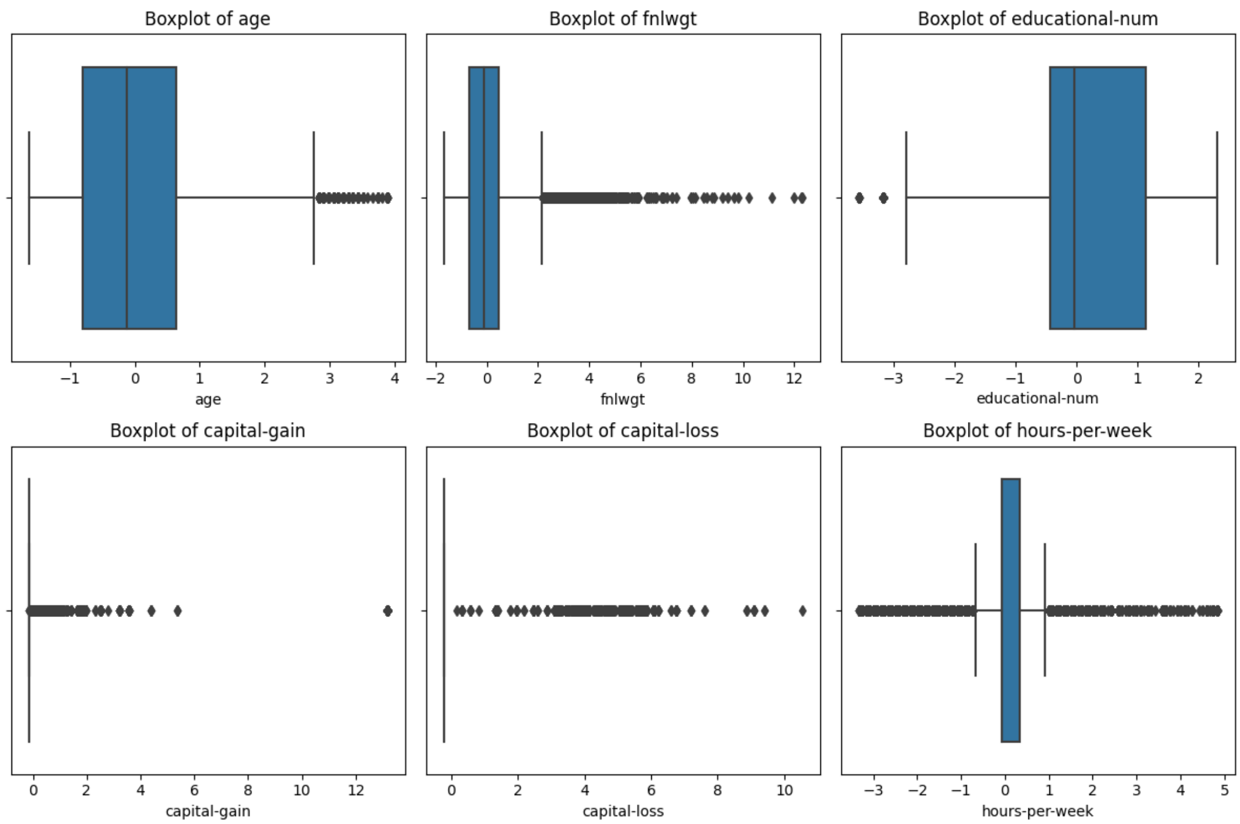



```
exp_transformed = np.exp(df[numeric_feature])
plt.subplot(4, 2, 7)  # Use 7 for the histogram
sns.histplot(exp_transformed, kde=True)
plt.title(f'Exponential Transformed {numeric_feature}')

plt.subplot(4, 2, 8)  # Use 8 for the Q-Q plot
stats.probplot(exp_transformed, dist="norm", plot=plt)
plt.title(f'Q-Q Plot for Exponential Transformed {numeric_feature}')
```

```
Text(0.5, 1.0, 'Q-Q Plot for Exponential Transformed capital-gain')
```




```
X = df.drop('income', axis=1)
y = df['income']

X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.2, random_state=42)

numeric_features = ['age', 'fnlwgt', 'educational-num', 'capital-
gain', 'capital-loss', 'hours-per-week']

plt.figure(figsize=(12, 8))
for i, feature in enumerate(numeric_features, 1):
    plt.subplot(2, 3, i)
    sns.boxplot(data=df, x=feature)
    plt.title(f'Boxplot of {feature}')
plt.tight_layout()
plt.show()
```




```
Q1 = df[numeric_feature].quantile(0.25)
Q3 = df[numeric_feature].quantile(0.75)
IQR = Q3 - Q1

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

# Remove outliers

df = df[(df[numeric_feature] >= lower_bound) & (df[numeric_feature] <=
upper_bound)]


# Verify that outliers have been removed

print(f"Number of rows after removing outliers: {len(df)}")

Number of rows after removing outliers: 41432
```