Module 6 - Final Project

In [1]:

```python
# Import Necessary Libraries and Data
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import warnings
warnings.filterwarnings("ignore")
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import OneHotEncoder
from sklearn.compose import make_column_transformer
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.tree import DecisionTreeClassifier, plot_tree
from sklearn.ensemble import RandomForestClassifier
from sklearn import tree
from sklearn.metrics import confusion_matrix,classification_report,accurac
from sklearn.datasets import make_classification
import statsmodels.api as sm
from sklearn.linear_model import Ridge
import xgboost as xgb
from category_encoders import TargetEncoder
from sklearn.feature_selection import RFE
from sklearn.linear_model import LogisticRegression
from sklearn.linear_model import Ridge
from sklearn.preprocessing import StandardScaler

# data location
data_url = 'C:/Users/Shivi Jain/OneDrive/Desktop/Data Mining/Module 1/data

# Read the given CSV file
a_df = pd.read_csv(data_url, sep= ';')

#View few records of the dataset
a_df.head()
```

Out[1]:

	Marital status	Application mode	Application order	Course	Daytime/evening attendance\t	Previous qualification	Previous qualification (grade)	Na
0	1	17	5	171	1	1	122.0	
1	1	15	1	9254	1	1	160.0	
2	1	1	5	9070	1	1	122.0	
3	1	17	2	9773	1	1	122.0	
4	2	39	1	8014	0	1	100.0	

5 rows × 37 columns

In [2]:

```
# To display the Dataframe structure

print('\n Dataframe has', a_df.shape, 'rows and columns respectively')
```

```
 Dataframe has (4424, 37) rows and columns respectively
```

Data Cleaning and Preperation

In [3]:

```
#check null values
a_df.isnull()

# Check for null values column by column
null_columns = a_df.columns[a_df.isnull().any()]
for column in null_columns:
    print(f"Column '{column}' has null values.")
```

In [4]:

```python
# Calculate the percentage of 'null' data in each column
for column in a_df.columns:
    null_count = a_df[column].isnull().sum()
    total_count = len(a_df[column])
    percentage = (null_count / total_count) * 100
    print(f"Column '{column}': {percentage:.3f}% of null data.")
```

```
Column 'Marital status': 0.000% of null data.
Column 'Application mode': 0.000% of null data.
Column 'Application order': 0.000% of null data.
Column 'Course': 0.000% of null data.
Column 'Daytime/evening attendance      ': 0.000% of null data.
Column 'Previous qualification': 0.000% of null data.
Column 'Previous qualification (grade)': 0.000% of null data.
Column 'Nacionality': 0.000% of null data.
Column 'Mother's qualification': 0.000% of null data.
Column 'Father's qualification': 0.000% of null data.
Column 'Mother's occupation': 0.000% of null data.
Column 'Father's occupation': 0.000% of null data.
Column 'Admission grade': 0.000% of null data.
Column 'Displaced': 0.000% of null data.
Column 'Educational special needs': 0.000% of null data.
Column 'Debtor': 0.000% of null data.
Column 'Tuition fees up to date': 0.000% of null data.
Column 'Gender': 0.000% of null data.
Column 'Scholarship holder': 0.000% of null data.
Column 'Age at enrollment': 0.000% of null data.
Column 'International': 0.000% of null data.
Column 'Curricular units 1st sem (credited)': 0.000% of null data.
Column 'Curricular units 1st sem (enrolled)': 0.000% of null data.
Column 'Curricular units 1st sem (evaluations)': 0.000% of null data.
Column 'Curricular units 1st sem (approved)': 0.000% of null data.
Column 'Curricular units 1st sem (grade)': 0.000% of null data.
Column 'Curricular units 1st sem (without evaluations)': 0.000% of null d
ata.
Column 'Curricular units 2nd sem (credited)': 0.000% of null data.
Column 'Curricular units 2nd sem (enrolled)': 0.000% of null data.
Column 'Curricular units 2nd sem (evaluations)': 0.000% of null data.
Column 'Curricular units 2nd sem (approved)': 0.000% of null data.
Column 'Curricular units 2nd sem (grade)': 0.000% of null data.
Column 'Curricular units 2nd sem (without evaluations)': 0.000% of null d
ata.
Column 'Unemployment rate': 0.000% of null data.
Column 'Inflation rate': 0.000% of null data.
Column 'GDP': 0.000% of null data.
Column 'Target': 0.000% of null data.
```

In [5]:

```
#Drop unwanted columns:
a_df = a_df.drop(columns=['Application order','Application mode','Displace
                          'Curricular units 1st sem (enrolled)','Curricular
                          'Curricular units 1st sem (approved)','Curricular
                          'Curricular units 2nd sem (credited)','Curricular
                          'Curricular units 2nd sem (evaluations)','Curricu
                          'Curricular units 2nd sem (without evaluations)']
a_df.head()
```

Out[5]:

	Marital status	Course	Daytime/evening attendance\t	Previous qualification	Previous qualification (grade)	Nacionality	Mother's qualification	q
0	1	171	1	1	122.0	1	19	
1	1	9254	1	1	160.0	1	1	
2	1	9070	1	1	122.0	1	37	
3	1	9773	1	1	122.0	1	38	
4	2	8014	0	1	100.0	1	37	

5 rows × 24 columns

In [6]:

```
#Rename the columns:
a_df = a_df.rename(columns={'Daytime/evening attendance\t': 'Daytime/eveni
```

In [7]:

```
values = {1: 'single',
          2: 'married',
          3: 'widower',
          4: 'divorced',
          5: 'facto union',
          6: 'legally separated'}

a_df["Marital status"] = a_df["Marital status"].apply(lambda x: values[x]

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status  Course  Daytime/evening attendance  Previous qualificat
ion  \
0         single     171                           1
1
1         single    9254                           1
1
2         single    9070                           1
1
3         single    9773                           1
1
4        married    8014                           0
1

   Previous qualification (grade)  Nacionality  Mother's qualification  \
0                           122.0            1                      19
1                           160.0            1                       1
2                           122.0            1                      37
3                           122.0            1                      38
4                           100.0            1                      37

   Father's qualification  Mother's occupation  Father's occupation  ...
\
0                      12                    5                    9  ...
1                       3                    3                    3  ...
2                      37                    9                    9  ...
3                      37                    5                    3  ...
4                      38                    9                    9  ...

   Gender  Scholarship holder  Age at enrollment  International  \
0       1                   0                 20              0
1       1                   0                 19              0
2       1                   0                 19              0
3       0                   0                 20              0
4       0                   0                 45              0

   Curricular units 1st sem (grade)  Curricular units 2nd sem (grade)  \
0                          0.000000                          0.000000
1                         14.000000                         13.666667
2                          0.000000                          0.000000
3                         13.428571                         12.400000
4                         12.333333                         13.000000

   Unemployment rate  Inflation rate   GDP    Target
0               10.8             1.4  1.74   Dropout
1               13.9            -0.3  0.79  Graduate
2               10.8             1.4  1.74   Dropout
3                9.4            -0.8 -3.12  Graduate
4               13.9            -0.3  0.79  Graduate

[5 rows x 24 columns]
```

In [8]:

```
values= {33: 'Biofuel Production Technologies',
         171: 'Animation and Multimedia Design',
         8014: 'Social Service (evening attendance)',
         9003: 'Agronomy',
         9070: 'Communication Design',
         9085: 'Veterinary Nursing',
         9119: 'Informatics Engineering',
         9130: 'Equinculture',
         9147: 'Management',
         9238: 'Social Service',
         9254: 'Tourism',
         9500: 'Nursing',
         9556: 'Oral Hygiene',
         9670: 'Advertising and Marketing Management',
         9773: 'Journalism and Communication',
         9853: 'Basic Education',
         9991: 'Management (evening attendance)'}

a_df["Course"] = a_df["Course"].apply(lambda x: values[x] if x in values e

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance  Previous qualification  \
0                           1                       1
1                           1                       1
2                           1                       1
3                           1                       1
4                           0                       1

   Previous qualification (grade)  Nacionality  Mother's qualification  \
0                           122.0            1                      19
1                           160.0            1                       1
2                           122.0            1                      37
3                           122.0            1                      38
4                           100.0            1                      37

   Father's qualification  Mother's occupation  Father's occupation  ...
\
0                      12                    5                    9  ...
1                       3                    3                    3  ...
2                      37                    9                    9  ...
3                      37                    5                    3  ...
4                      38                    9                    9  ...

   Gender  Scholarship holder  Age at enrollment  International  \
0       1                   0                 20              0
1       1                   0                 19              0
2       1                   0                 19              0
3       0                   0                 20              0
4       0                   0                 45              0

   Curricular units 1st sem (grade)  Curricular units 2nd sem (grade)  \
0                          0.000000                          0.000000
1                         14.000000                         13.666667
2                          0.000000                          0.000000
3                         13.428571                         12.400000
4                         12.333333                         13.000000

   Unemployment rate  Inflation rate   GDP    Target
0               10.8             1.4  1.74   Dropout
1               13.9            -0.3  0.79  Graduate
2               10.8             1.4  1.74   Dropout
3                9.4            -0.8 -3.12  Graduate
4               13.9            -0.3  0.79  Graduate

[5 rows x 24 columns]
```

In [9]:

```
values= {1 : 'Secondary education',
         2 : "Higher education - bachelor's degree",
         3 : 'Higher education - degree',
         4 : "Higher education - master's",
         5 : 'Higher education - doctorate',
         6 : 'Frequency of higher education',
         9 : '12th year of schooling - not completed',
         10 : '11th year of schooling - not completed',
         12 : 'Other - 11th year of schooling',
         14 : '10th year of schooling',
         15 : '10th year of schooling - not completed',
         19 : 'Basic education 3rd cycle (9th/10th/11th year) or equiv.',
         38 : 'Basic education 2nd cycle (6th/7th/8th year) or equiv.',
         39 : 'Technological specialization course',
         40 : 'Higher education - degree (1st cycle)',
         42 : 'Professional higher technical course',
         43 : 'Higher education - master (2nd cycle)'}

a_df["Previous qualification"] = a_df["Previous qualification"].apply(lamb

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade)  Nacionality  Mother's qualification  \
0                           122.0            1                      19
1                           160.0            1                       1
2                           122.0            1                      37
3                           122.0            1                      38
4                           100.0            1                      37

   Father's qualification  Mother's occupation  Father's occupation  ...
\
0                      12                    5                    9  ...
1                       3                    3                    3  ...
2                      37                    9                    9  ...
3                      37                    5                    3  ...
4                      38                    9                    9  ...

   Gender  Scholarship holder  Age at enrollment  International  \
0       1                   0                 20              0
1       1                   0                 19              0
2       1                   0                 19              0
3       0                   0                 20              0
4       0                   0                 45              0

   Curricular units 1st sem (grade)  Curricular units 2nd sem (grade)  \
0                          0.000000                          0.000000
1                         14.000000                         13.666667
2                          0.000000                          0.000000
3                         13.428571                         12.400000
4                         12.333333                         13.000000

   Unemployment rate  Inflation rate   GDP    Target
0               10.8             1.4  1.74   Dropout
1               13.9            -0.3  0.79  Graduate
2               10.8             1.4  1.74   Dropout
3                9.4            -0.8 -3.12  Graduate
4               13.9            -0.3  0.79  Graduate

[5 rows x 24 columns]
```

In [10]:

```
values= {1 : 'Portuguese',
         2 : 'German',
         6 : 'Spanish',
         11 : 'Italian',
         13 : 'Dutch',
         14 : 'English',
         17 : 'Lithuanian',
         21 : 'Angolan',
         22 : 'Cape Verdean',
         24 : 'Guinean',
         25 : 'Mozambican',
         26 : 'Santomean',
         32 : 'Turkish',
         41 : 'Brazilian',
         62 : 'Romanian',
         100 : 'Moldova (Republic of)',
         101 : 'Mexican',
         103 : 'Ukrainian',
         105 : 'Russian',
         108 : 'Cuban',
         109 : 'Colombian'}

a_df["Nacionality"] = a_df["Nacionality"].apply(lambda x: values[x] if x i

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade) Nacionality  Mother's qualification  \
0                           122.0  Portuguese                      19
1                           160.0  Portuguese                       1
2                           122.0  Portuguese                      37
3                           122.0  Portuguese                      38
4                           100.0  Portuguese                      37

   Father's qualification  Mother's occupation  Father's occupation  ...
\
0                      12                    5                    9  ...
1                       3                    3                    3  ...
2                      37                    9                    9  ...
3                      37                    5                    3  ...
4                      38                    9                    9  ...

   Gender  Scholarship holder  Age at enrollment  International  \
0       1                   0                 20              0
1       1                   0                 19              0
2       1                   0                 19              0
3       0                   0                 20              0
4       0                   0                 45              0

   Curricular units 1st sem (grade)  Curricular units 2nd sem (grade)  \
0                          0.000000                          0.000000
1                         14.000000                         13.666667
2                          0.000000                          0.000000
3                         13.428571                         12.400000
4                         12.333333                         13.000000

   Unemployment rate  Inflation rate   GDP    Target
0               10.8             1.4  1.74   Dropout
1               13.9            -0.3  0.79  Graduate
2               10.8             1.4  1.74   Dropout
3                9.4            -0.8 -3.12  Graduate
4               13.9            -0.3  0.79  Graduate

[5 rows x 24 columns]
```

In [11]:

```
values= {1 : 'Secondary Education - 12th Year of Schooling or Eq.',
         2 : "Higher Education - Bachelor's Degree",
         3 : 'Higher Education - Degree',
         4 : "Higher Education - Master's",
         5 : "Higher Education - Doctorate",
         6 : 'Frequency of Higher Education',
         9 : '12th Year of Schooling - Not Completed',
         10 : '11th Year of Schooling - Not Completed',
         11 : '7th Year (Old)',
         12 : 'Other - 11th Year of Schooling',
         14 : '10th Year of Schooling',
         18 : 'General commerce course',
         19 : 'Basic Education 3rd Cycle (9th/10th/11th Year) or Equiv.',
         22 : 'Technical-professional course',
         26 : '7th year of schooling',
         27 : '2nd cycle of the general high school course',
         29 : '9th Year of Schooling - Not Completed',
         30 : '8th year of schooling',
         34 : 'Unknown',
         35 : "Can't read or write",
         36 : 'Can read without having a 4th year of schooling',
         37 : 'Basic education 1st cycle (4th/5th year) or equiv.',
         38 : 'Basic Education 2nd Cycle (6th/7th/8th Year) or Equiv.',
         39 : 'Technological specialization course',
         40 : 'Higher education - degree (1st cycle)',
         41 : 'Specialized higher studies course',
         42 : 'Professional higher technical course',
         43 : 'Higher Education - Master (2nd cycle)',
         44 : 'Higher Education - Doctorate (3rd cycle)'}

a_df["Mother's qualification"] = a_df["Mother's qualification"].apply(lamb

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade) Nacionality  \
0                           122.0  Portuguese
1                           160.0  Portuguese
2                           122.0  Portuguese
3                           122.0  Portuguese
4                           100.0  Portuguese

                              Mother's qualification  Father's qualificat
ion  \
0  Basic Education 3rd Cycle (9th/10th/11th Year)...
12
1  Secondary Education - 12th Year of Schooling o...
3
2  Basic education 1st cycle (4th/5th year) or eq...
37
3  Basic Education 2nd Cycle (6th/7th/8th Year) o...
37
4  Basic education 1st cycle (4th/5th year) or eq...
38

   Mother's occupation  Father's occupation  ...  Gender  Scholarship hol
der  \
0                    5                    9  ...       1
0
1                    3                    3  ...       1
0
2                    9                    9  ...       1
0
3                    5                    3  ...       0
0
4                    9                    9  ...       0
0

   Age at enrollment  International  Curricular units 1st sem (grade)  \
0                 20              0                          0.000000
1                 19              0                         14.000000
2                 19              0                          0.000000
3                 20              0                         13.428571
4                 45              0                         12.333333

   Curricular units 2nd sem (grade)  Unemployment rate  Inflation rate
GDP  \
0                          0.000000               10.8             1.4
```

```
1.74
1                        13.666667              13.9           -0.3
0.79
2                         0.000000              10.8            1.4
1.74
3                        12.400000               9.4           -0.8 -
3.12
4                        13.000000              13.9           -0.3
0.79

     Target
0   Dropout
1  Graduate
2   Dropout
3  Graduate
4  Graduate

[5 rows x 24 columns]
```

In [12]:

```
values= {1 : 'Secondary Education - 12th Year of Schooling or Eq.',
         2 : "Higher Education - Bachelor's Degree",
         3 : 'Higher Education - Degree',
         4 : "Higher Education - Master's",
         5 : 'Higher Education - Doctorate',
         6 : 'Frequency of Higher Education',
         9 : '12th Year of Schooling - Not Completed',
         10 : '11th Year of Schooling - Not Completed',
         11 : '7th Year (Old)',
         12 : 'Other - 11th Year of Schooling',
         13 : '2nd year complementary high school course',
         14 : '10th Year of Schooling',
         18 : 'General commerce course',
         19 : 'Basic Education 3rd Cycle (9th/10th/11th Year) or Equiv.',
         20 : 'Complementary High School Course',
         22 : 'Technical-professional course',
         25 : 'Complementary High School Course - not concluded',
         26 : '7th year of schooling',
         27 : '2nd cycle of the general high school course',
         29 : '9th Year of Schooling - Not Completed',
         30 : '8th year of schooling',
         31 : 'General Course of Administration and Commerce',
         33 : 'Supplementary Accounting and Administration',
         34 : 'Unknown',
         35 : "Can't read or write",
         36 : 'Can read without having a 4th year of schooling',
         37 : 'Basic education 1st cycle (4th/5th year) or equiv.',
         38 : 'Basic Education 2nd Cycle (6th/7th/8th Year) or Equiv.',
         39 : 'Technological specialization course',
         40 : 'Higher education - degree (1st cycle)',
         41 : 'Specialized higher studies course',
         42 : 'Professional higher technical course',
         43 : 'Higher Education - Master (2nd cycle)',
         44 : 'Higher Education - Doctorate (3rd cycle)'}

a_df["Father's qualification"] = a_df["Father's qualification"].apply(lamb

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade) Nacionality  \
0                           122.0  Portuguese
1                           160.0  Portuguese
2                           122.0  Portuguese
3                           122.0  Portuguese
4                           100.0  Portuguese

                             Mother's qualification  \
0  Basic Education 3rd Cycle (9th/10th/11th Year)...
1  Secondary Education - 12th Year of Schooling o...
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic Education 2nd Cycle (6th/7th/8th Year) o...
4  Basic education 1st cycle (4th/5th year) or eq...

                             Father's qualification  Mother's occupation
\
0                     Other - 11th Year of Schooling                    5
1                          Higher Education - Degree                    3
2  Basic education 1st cycle (4th/5th year) or eq...                    9
3  Basic education 1st cycle (4th/5th year) or eq...                    5
4  Basic Education 2nd Cycle (6th/7th/8th Year) o...                    9

   Father's occupation  ...  Gender  Scholarship holder  Age at enrollmen
t  \
0                    9  ...       1                   0                 2
0
1                    3  ...       1                   0                 1
9
2                    9  ...       1                   0                 1
9
3                    3  ...       0                   0                 2
0
4                    9  ...       0                   0                 4
5

   International  Curricular units 1st sem (grade)  \
0              0                          0.000000
1              0                         14.000000
2              0                          0.000000
3              0                         13.428571
4              0                         12.333333

   Curricular units 2nd sem (grade)  Unemployment rate  Inflation rate
```

```
GDP  \
0                          0.000000               10.8             1.4
1.74
1                         13.666667               13.9            -0.3
0.79
2                          0.000000               10.8             1.4
1.74
3                         12.400000                9.4            -0.8 -
3.12
4                         13.000000               13.9            -0.3
0.79

     Target
0   Dropout
1  Graduate
2   Dropout
3  Graduate
4  Graduate

[5 rows x 24 columns]
```

In [13]:

```
values= {0: 'Student',
         1: 'Representatives of the Legislative Power and Executive Bodies
         2: 'Intellectual and Scientific Specialists',
         3: 'Intermediate Level Technicians',
         4: 'Administrative staff',
         5: 'Personal Services, Security and Safety Workers',
         6: 'Farmers and Skilled Workers in Agriculture, Fisheries and For
         7: 'Skilled Workers in Industry, Construction and Craftsmen',
         8: 'Installation and Machine Operators and Assembly Workers',
         9: 'Unskilled Workers',
         10: 'Armed Forces Professions',
         90: 'Other Situation',
         99: 'Unknown',
         122: 'Health professionals',
         123: 'teachers',
         125: 'Specialists in ICT',
         131: 'Intermediate level science and engineering technicians and
         132: 'Intermediate level Technicians and Health professionals',
         134: 'Intermediate level technicians from legal, social, sports,
         141: 'Office workers, secretaries and data processing operators',
         143: 'Data, accounting, statistical, financial services and regis
         144: 'Other administrative support staff',
         151: 'personal service workers',
         152: 'sellers',
         153: 'Personal care workers',
         171: 'Skilled construction workers except electricians',
         173: 'Skilled workers in printing, precision instrument manufactu
         175: 'Workers in food processing, woodworking, clothing and other
         191: 'Cleaning workers',
         192: 'Unskilled workers in agriculture, animal production, fisher
         193: 'Unskilled workers in extractive industry, construction, man
         194: 'Meal preparation assistants'}

a_df["Mother's occupation"] = a_df["Mother's occupation"].apply(lambda x:

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade) Nacionality  \
0                           122.0  Portuguese
1                           160.0  Portuguese
2                           122.0  Portuguese
3                           122.0  Portuguese
4                           100.0  Portuguese

                              Mother's qualification  \
0  Basic Education 3rd Cycle (9th/10th/11th Year)...
1  Secondary Education - 12th Year of Schooling o...
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic Education 2nd Cycle (6th/7th/8th Year) o...
4  Basic education 1st cycle (4th/5th year) or eq...

                              Father's qualification  \
0                     Other - 11th Year of Schooling
1                          Higher Education - Degree
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic education 1st cycle (4th/5th year) or eq...
4  Basic Education 2nd Cycle (6th/7th/8th Year) o...

                              Mother's occupation  Father's occupation
...  \
0  Personal Services, Security and Safety Workers                    9
...
1                 Intermediate Level Technicians                     3
...
2                              Unskilled Workers                     9
...
3  Personal Services, Security and Safety Workers                    3
...
4                              Unskilled Workers                     9
...

   Gender  Scholarship holder  Age at enrollment  International  \
0       1                   0                 20              0
1       1                   0                 19              0
2       1                   0                 19              0
3       0                   0                 20              0
4       0                   0                 45              0

   Curricular units 1st sem (grade)  Curricular units 2nd sem (grade)  \
0                          0.000000                          0.000000
```

1	14.000000	13.666667
2	0.000000	0.000000
3	13.428571	12.400000
4	12.333333	13.000000

	Unemployment rate	Inflation rate	GDP	Target
0	10.8	1.4	1.74	Dropout
1	13.9	-0.3	0.79	Graduate
2	10.8	1.4	1.74	Dropout
3	9.4	-0.8	-3.12	Graduate
4	13.9	-0.3	0.79	Graduate

[5 rows x 24 columns]

In [14]:

```
values= {0: 'Student',
         1: 'Representatives of the Legislative Power and Executive Bodies
         2: 'Intellectual and Scientific Specialists',
         3: 'Intermediate Level Technicians and Professions',
         4: 'Administrative staff',
         5: 'Personal Services, Security and Safety Workers/Sellers',
         6: 'Farmers and Skilled Workers in Agriculture, Fisheries and For
         7: 'Skilled Workers in Industry, Construction and Craftsmen',
         8: 'Installation and Machine Operators and Assembly Workers',
         9: 'Unskilled Workers',
         10: 'Armed Forces Professions',
         90: 'Other Situation',
         99: 'Unknown',
         101: 'Armed Forces Officers',
         102: 'Armed Forces Sergeants',
         103: 'Other Armed Forces personnel',
         112: 'Directors of administrative and commercial services',
         114: 'Hotel, catering, trade and other services directors',
         121: 'Specialists in the physical sciences, mathematics, engineer
         122: 'Health professionals',
         123: 'Teachers',
         124: 'Specialists in finance, accounting, administrative organiza
         131: 'Intermediate level science and engineering technicians and
         132: 'Intermediate level Technicians and Health professionals',
         134: 'Intermediate level technicians from legal, social, sports,
         135: 'Information and communication technology technicians',
         141: 'Office workers/secretaries and data processing operators',
         143: 'Data, accounting, statistical, financial services and regis
         144: 'Other administrative support staff',
         151: 'personal service workers',
         152: 'sellers',
         153: 'Personal care workers',
         154: 'Protection and security services personnel',
         161: 'Market-oriented farmers and skilled agricultural and animal
         163: 'Farmers, livestock keepers, fishermen, hunters and gatherer
         171: 'Skilled construction workers except electricians',
         172: 'Skilled workers in metallurgy, metalworking',
         174: 'Skilled workers in electricity and electronics',
         175: 'Workers in food processing, woodworking, clothing and other
         181: 'Fixed plant and machine operators',
         182: 'assembly workers',
         183: 'Vehicle drivers and mobile equipment operators',
         192: 'Unskilled workers in agriculture, animal production, fisher
         193: 'Unskilled workers in extractive industry, construction, man
         194: 'Meal preparation assistants',
         195: 'Street vendors (except food) and street service providers'}

a_df["Father's occupation"] = a_df["Father's occupation"].apply(lambda x:

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade) Nacionality  \
0                           122.0  Portuguese
1                           160.0  Portuguese
2                           122.0  Portuguese
3                           122.0  Portuguese
4                           100.0  Portuguese

                             Mother's qualification  \
0  Basic Education 3rd Cycle (9th/10th/11th Year)...
1  Secondary Education - 12th Year of Schooling o...
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic Education 2nd Cycle (6th/7th/8th Year) o...
4  Basic education 1st cycle (4th/5th year) or eq...

                             Father's qualification  \
0                     Other - 11th Year of Schooling
1                          Higher Education - Degree
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic education 1st cycle (4th/5th year) or eq...
4  Basic Education 2nd Cycle (6th/7th/8th Year) o...

                             Mother's occupation  \
0  Personal Services, Security and Safety Workers
1                 Intermediate Level Technicians
2                              Unskilled Workers
3  Personal Services, Security and Safety Workers
4                              Unskilled Workers

                             Father's occupation  ...  Gender  \
0                              Unskilled Workers  ...       1
1  Intermediate Level Technicians and Professions  ...       1
2                              Unskilled Workers  ...       1
3  Intermediate Level Technicians and Professions  ...       0
4                              Unskilled Workers  ...       0

   Scholarship holder  Age at enrollment  International  \
0                   0                 20              0
1                   0                 19              0
2                   0                 19              0
3                   0                 20              0
4                   0                 45              0

   Curricular units 1st sem (grade)  Curricular units 2nd sem (grade)  \
```

0	0.000000	0.000000
1	14.000000	13.666667
2	0.000000	0.000000
3	13.428571	12.400000
4	12.333333	13.000000

	Unemployment rate	Inflation rate	GDP	Target
0	10.8	1.4	1.74	Dropout
1	13.9	-0.3	0.79	Graduate
2	10.8	1.4	1.74	Dropout
3	9.4	-0.8	-3.12	Graduate
4	13.9	-0.3	0.79	Graduate

[5 rows x 24 columns]

In [15]:

```
values = {1: 'male',
          0: 'female'}

a_df["Gender"] = a_df["Gender"].apply(lambda x: values[x] if x in values e

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade) Nacionality  \
0                           122.0  Portuguese
1                           160.0  Portuguese
2                           122.0  Portuguese
3                           122.0  Portuguese
4                           100.0  Portuguese

                             Mother's qualification  \
0  Basic Education 3rd Cycle (9th/10th/11th Year)...
1  Secondary Education - 12th Year of Schooling o...
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic Education 2nd Cycle (6th/7th/8th Year) o...
4  Basic education 1st cycle (4th/5th year) or eq...

                             Father's qualification  \
0                     Other - 11th Year of Schooling
1                          Higher Education - Degree
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic education 1st cycle (4th/5th year) or eq...
4  Basic Education 2nd Cycle (6th/7th/8th Year) o...

                             Mother's occupation  \
0  Personal Services, Security and Safety Workers
1                 Intermediate Level Technicians
2                              Unskilled Workers
3  Personal Services, Security and Safety Workers
4                              Unskilled Workers

                             Father's occupation  ...  Gender  \
0                              Unskilled Workers  ...    male
1  Intermediate Level Technicians and Professions  ...    male
2                              Unskilled Workers  ...    male
3  Intermediate Level Technicians and Professions  ...  female
4                              Unskilled Workers  ...  female

   Scholarship holder  Age at enrollment  International  \
0                   0                 20              0
1                   0                 19              0
2                   0                 19              0
3                   0                 20              0
4                   0                 45              0

  Curricular units 1st sem (grade)  Curricular units 2nd sem (grade)  \
```

```
0                         0.000000                         0.000000
1                        14.000000                        13.666667
2                         0.000000                         0.000000
3                        13.428571                        12.400000
4                        12.333333                        13.000000

   Unemployment rate  Inflation rate   GDP    Target
0               10.8             1.4  1.74   Dropout
1               13.9            -0.3  0.79  Graduate
2               10.8             1.4  1.74   Dropout
3                9.4            -0.8 -3.12  Graduate
4               13.9            -0.3  0.79  Graduate

[5 rows x 24 columns]
```

In [16]:

```python
#check the datatype of the columns
print(a_df.info())
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4424 entries, 0 to 4423
Data columns (total 24 columns):
 #   Column                          Non-Null Count  Dtype
---  ------                          --------------  -----
 0   Marital status                  4424 non-null   object
 1   Course                          4424 non-null   object
 2   Daytime/evening attendance      4424 non-null   int64
 3   Previous qualification          4424 non-null   object
 4   Previous qualification (grade)  4424 non-null   float64
 5   Nacionality                     4424 non-null   object
 6   Mother's qualification          4424 non-null   object
 7   Father's qualification          4424 non-null   object
 8   Mother's occupation             4424 non-null   object
 9   Father's occupation             4424 non-null   object
 10  Admission grade                 4424 non-null   float64
 11  Educational special needs       4424 non-null   int64
 12  Debtor                          4424 non-null   int64
 13  Tuition fees up to date         4424 non-null   int64
 14  Gender                          4424 non-null   object
 15  Scholarship holder              4424 non-null   int64
 16  Age at enrollment               4424 non-null   int64
 17  International                   4424 non-null   int64
 18  Curricular units 1st sem (grade)  4424 non-null   float64
 19  Curricular units 2nd sem (grade)  4424 non-null   float64
 20  Unemployment rate               4424 non-null   float64
 21  Inflation rate                  4424 non-null   float64
 22  GDP                             4424 non-null   float64
 23  Target                          4424 non-null   object
dtypes: float64(7), int64(7), object(10)
memory usage: 829.6+ KB
None
```

In [17]:

```
#Statistical Analysis
a_df.describe()
```

Out[17]:

	Daytime/evening attendance	Previous qualification (grade)	Admission grade	Educational special needs	Debtor	Tuition fees up to date
count	4424.000000	4424.000000	4424.000000	4424.000000	4424.000000	4424.000000
mean	0.890823	132.613314	126.978119	0.011528	0.113698	0.880651
std	0.311897	13.188332	14.482001	0.106760	0.317480	0.324235
min	0.000000	95.000000	95.000000	0.000000	0.000000	0.000000
25%	1.000000	125.000000	117.900000	0.000000	0.000000	1.000000
50%	1.000000	133.100000	126.100000	0.000000	0.000000	1.000000
75%	1.000000	140.000000	134.800000	0.000000	0.000000	1.000000
max	1.000000	190.000000	190.000000	1.000000	1.000000	1.000000

In [18]:

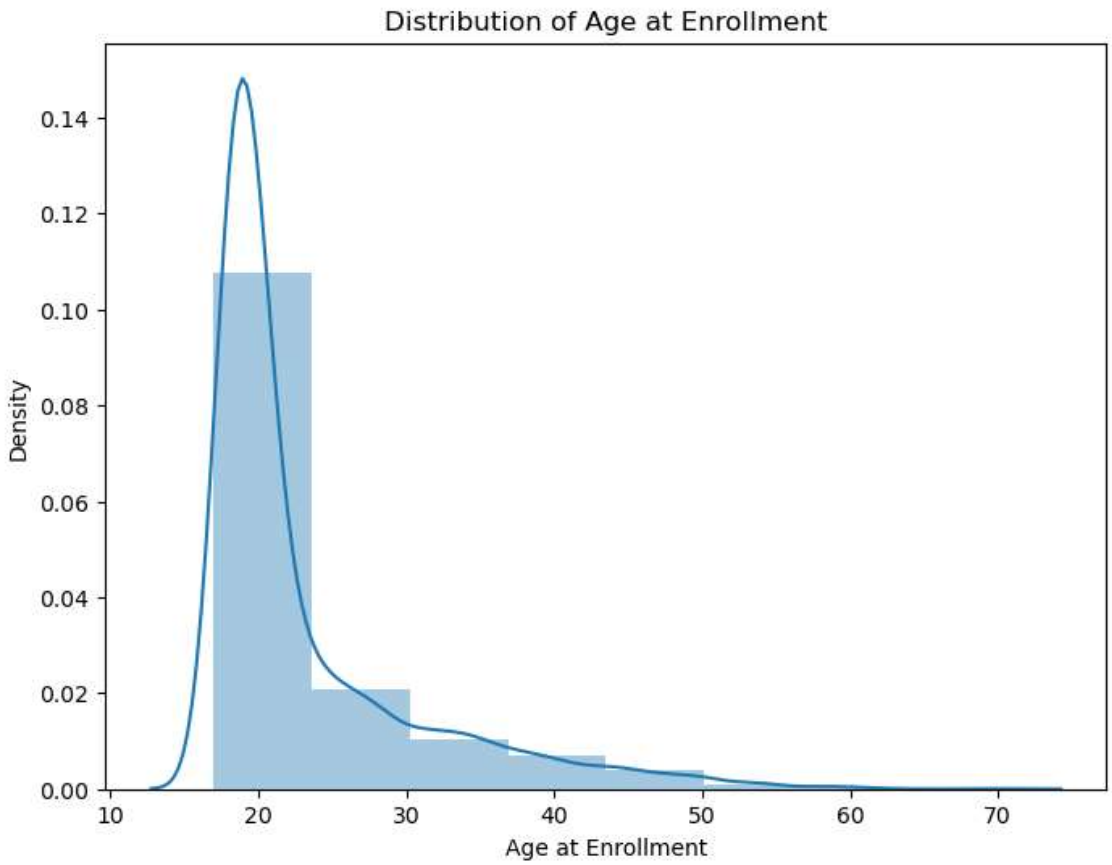
```
#show the unique values in each column
for column in a_df.columns:
    unique_values = a_df[column].unique()
    print(f"Unique values in column '{column}':")
    print(unique_values)
    print()
```

```
Unique values in column 'Marital status':
['single' 'married' 'divorced' 'widower' 'facto union' 'legally separa
ted']

Unique values in column 'Course':
['Animation and Multimedia Design' 'Tourism' 'Communication Design'
 'Journalism and Communication' 'Social Service (evening attendance)'
 'Management (evening attendance)' 'Nursing' 'Social Service'
 'Advertising and Marketing Management' 'Basic Education'
 'Veterinary Nursing' 'Equinculture' 'Oral Hygiene' 'Management'
 'Agronomy' 'Biofuel Production Technologies' 'Informatics Engineerin
g']

Unique values in column 'Daytime/evening attendance':
[1 0]

Unique values in column 'Previous qualification':
['Secondary education'
 'Basic education 3rd cycle (9th/10th/11th year) or equiv.'
```

Exploratory Data Analysis

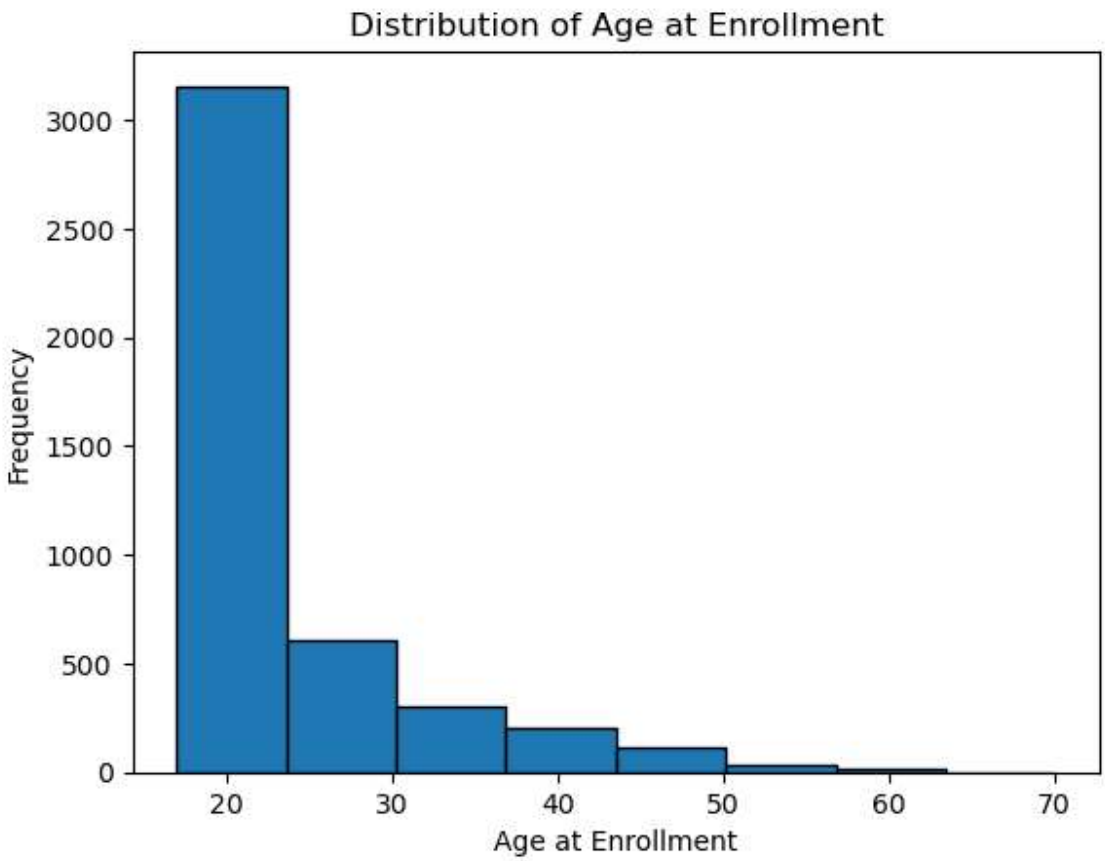
In [19]:

```
# Density and Histogram to see the distribution of Age

# Create a distribution plot
plt.figure(figsize=(8, 6))
sns.distplot(a_df['Age at enrollment'],bins=8)

# Customize the distribution plot
plt.title('Distribution of Age at Enrollment')
plt.xlabel('Age at Enrollment')
plt.ylabel('Density')

# Display the Distribution plot for age
plt.show()
```



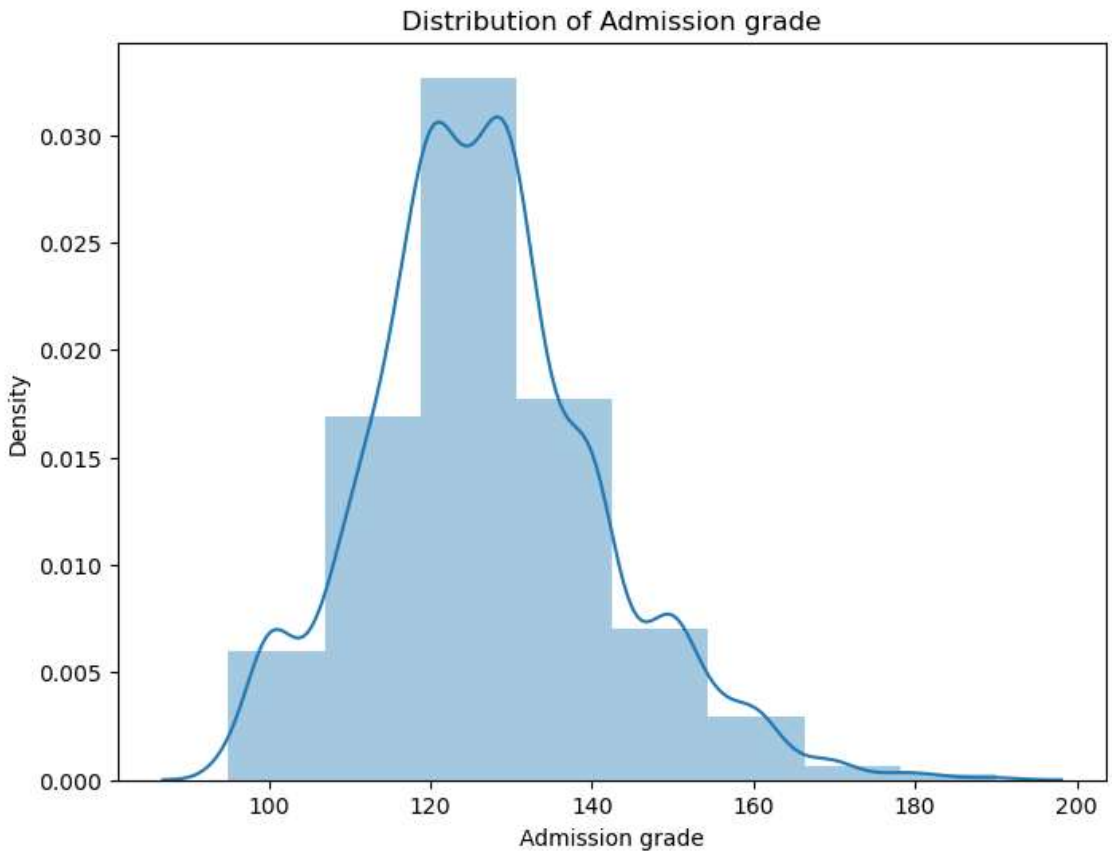
In [20]:

```
plt.hist(a_df['Age at enrollment'], bins=8, edgecolor='black')  # 'bins' d
plt.xlabel('Age at Enrollment')
plt.ylabel('Frequency')
plt.title('Distribution of Age at Enrollment')
plt.show()
```



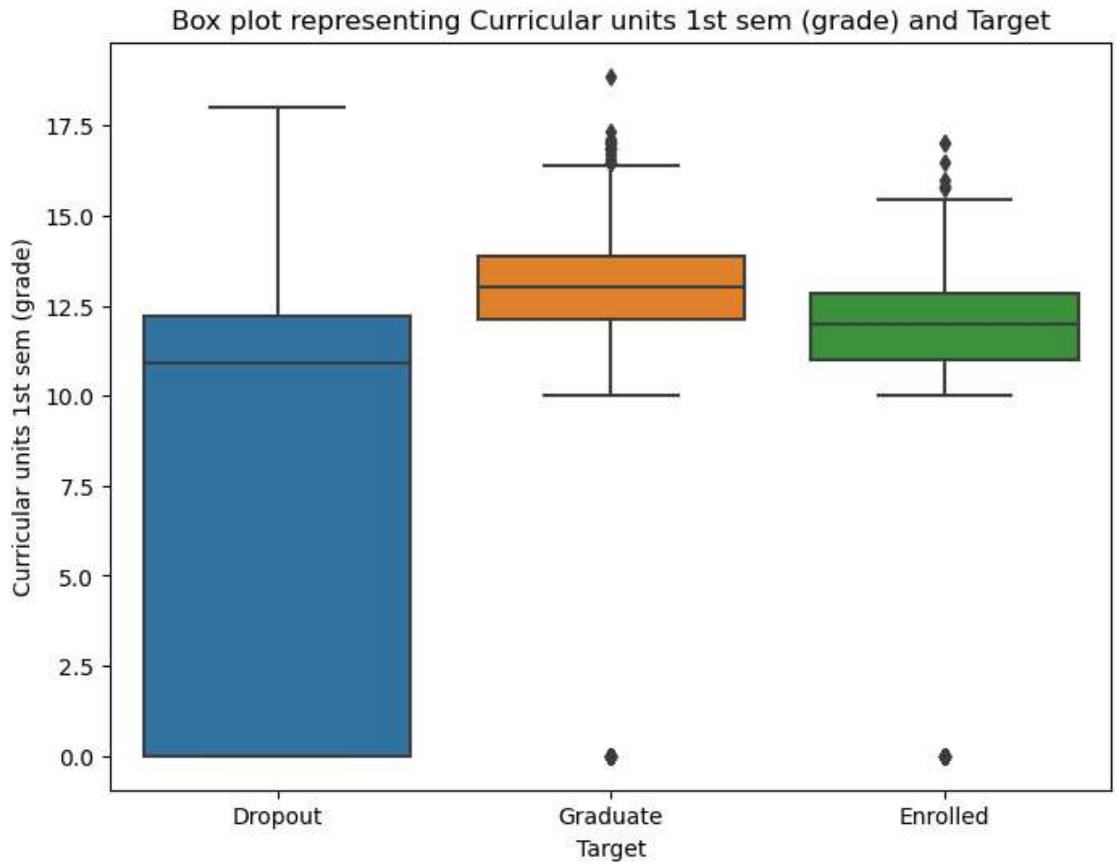
In [21]:

```
# Density and Histogram to see the distribution of Admission Grade

# Create a distribution plot
plt.figure(figsize=(8, 6))
sns.distplot(a_df['Admission grade'],bins=8)

# Customize the distribution plot
plt.title('Distribution of Admission grade')
plt.xlabel('Admission grade')
plt.ylabel('Density')

# Display the Distribution plot for age
plt.show()
```



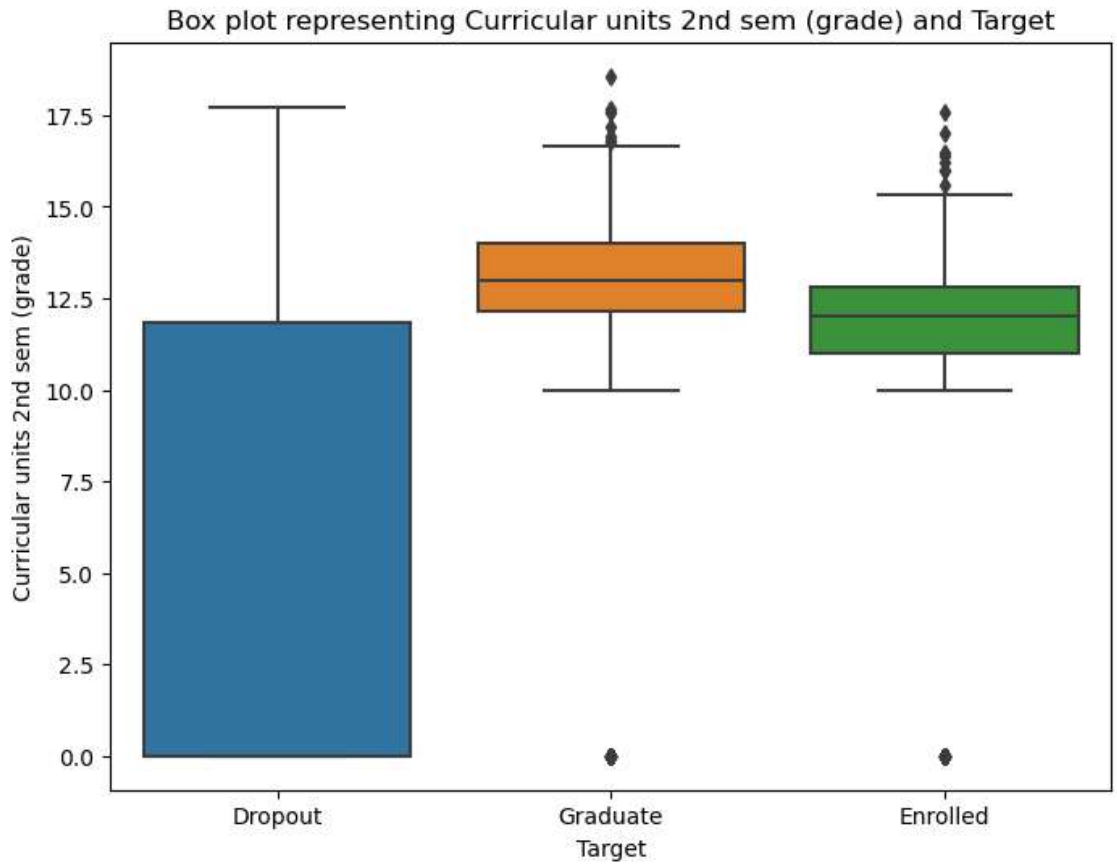
In [22]:

```
#Variation between target and 1st Term grade
plt.figure(figsize=(8, 6))
sns.boxplot(x=a_df['Target'],y=a_df['Curricular units 1st sem (grade)'])

# Customize the distribution plot
plt.title('Box plot representing Curricular units 1st sem (grade) and Targ
plt.xlabel('Target')
plt.ylabel('Curricular units 1st sem (grade)')

# Display the plot
plt.show()
```



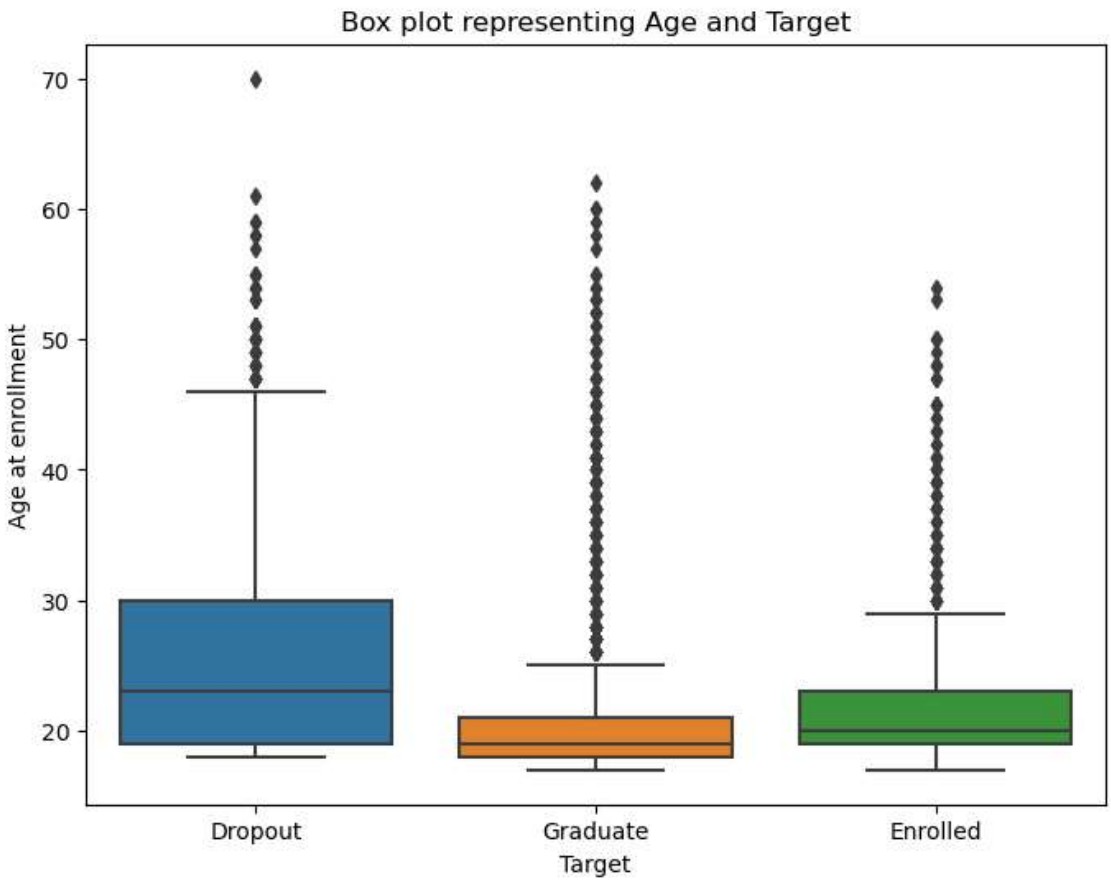
In [23]:

```
#Variation between target and 2nd sem grade
plt.figure(figsize=(8, 6))
sns.boxplot(x=a_df['Target'],y=a_df['Curricular units 2nd sem (grade)'])

# Customize the distribution plot
plt.title('Box plot representing Curricular units 2nd sem (grade) and Targ
plt.xlabel('Target')
plt.ylabel('Curricular units 2nd sem (grade)')

# Display the plot
plt.show()
```



In [24]:

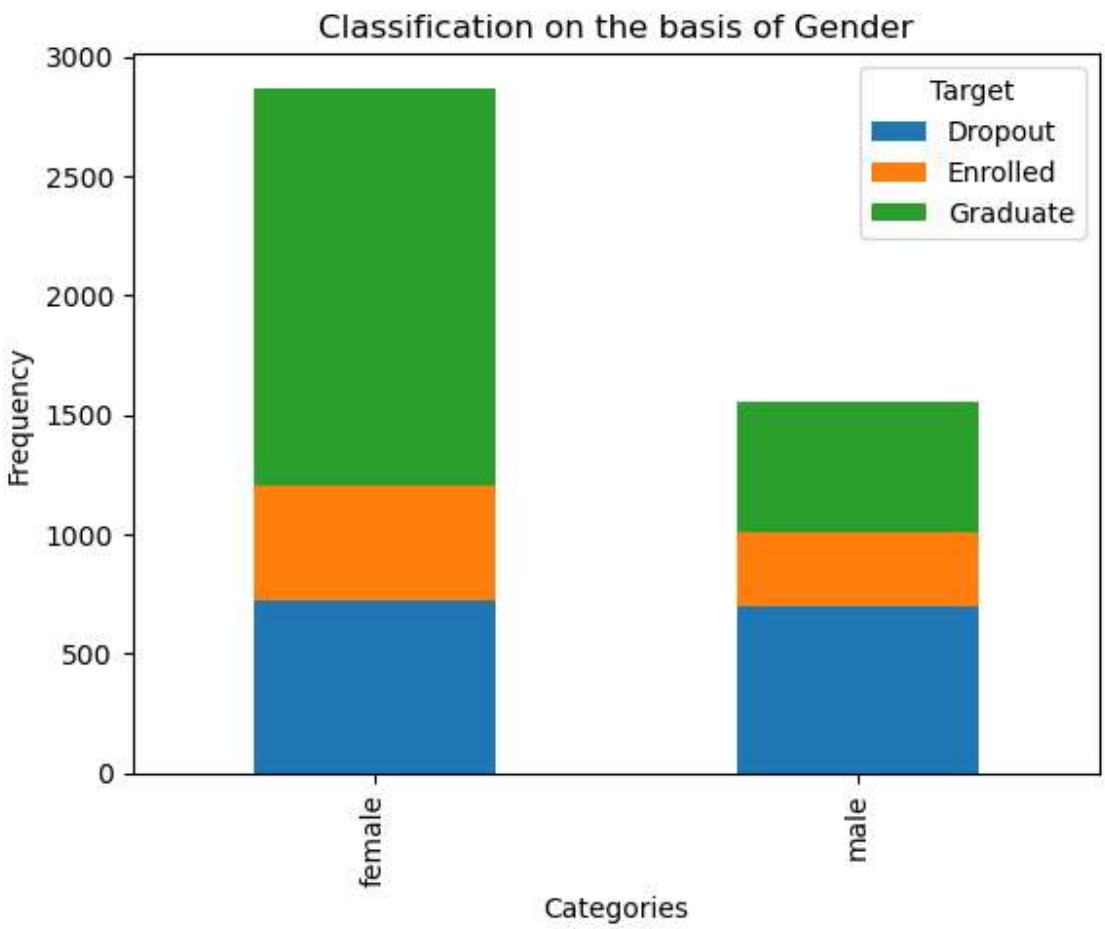
```
#Variation between age and target
plt.figure(figsize=(8, 6))
sns.boxplot(x=a_df['Target'],y=a_df['Age at enrollment'])

# Customize the distribution plot
plt.title('Box plot representing Age and Target')
plt.xlabel('Target')
plt.ylabel('Age at enrollment')

# Display the plot
plt.show()
```



In [25]:

```
# Count the frequency of each category
category_counts = a_df.groupby(['Gender', 'Target']).size().unstack()

category_counts['Total'] = category_counts.sum(axis=1)
category_counts = category_counts.sort_values(by='Total', ascending=False)


# Plot the bar chart
plt.figure(figsize=(8, 6))
category_counts.plot(kind='bar',stacked ='True')

# Customize the chart
plt.title('Classification on the basis of Gender')
plt.ylabel('Frequency')
plt.xlabel('Categories')

# Show the plot
plt.show()
```

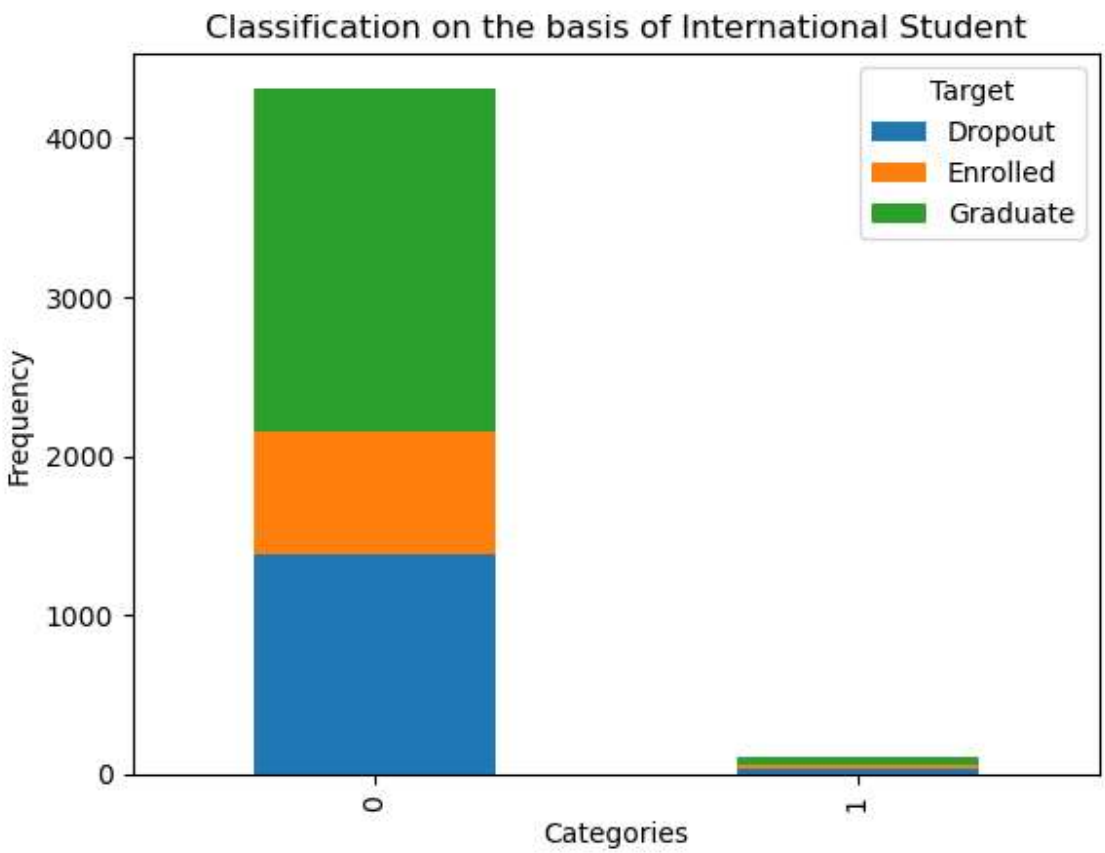
```
<Figure size 800x600 with 0 Axes>
```



In [26]:

```
# Count the frequency of each category
category_counts = a_df.groupby(['International', 'Target']).size().unstack

category_counts['Total'] = category_counts.sum(axis=1)
category_counts = category_counts.sort_values(by='Total', ascending=False)


# Plot the bar chart
plt.figure(figsize=(8, 6))
category_counts.plot(kind='bar',stacked ='True')

# Customize the chart
plt.title('Classification on the basis of International Student')
plt.ylabel('Frequency')
plt.xlabel('Categories')

# Show the plot
plt.show()
```

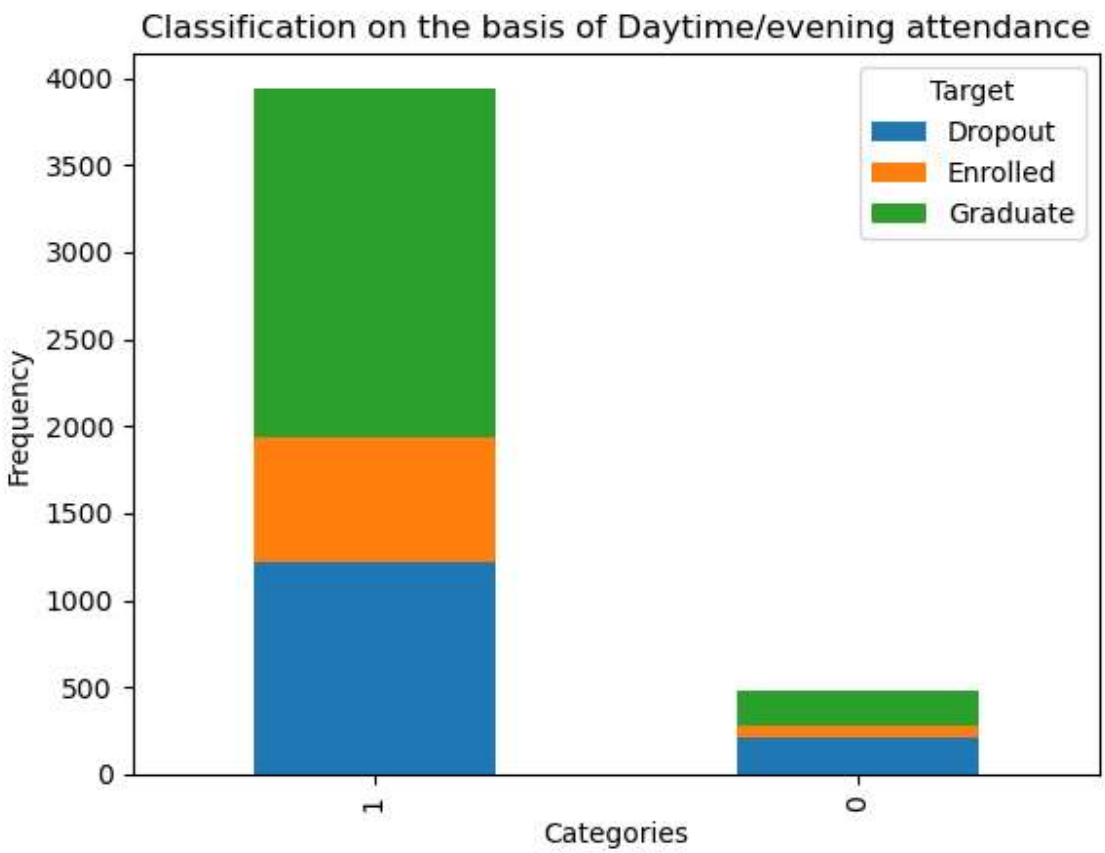
```
<Figure size 800x600 with 0 Axes>
```



In [27]:

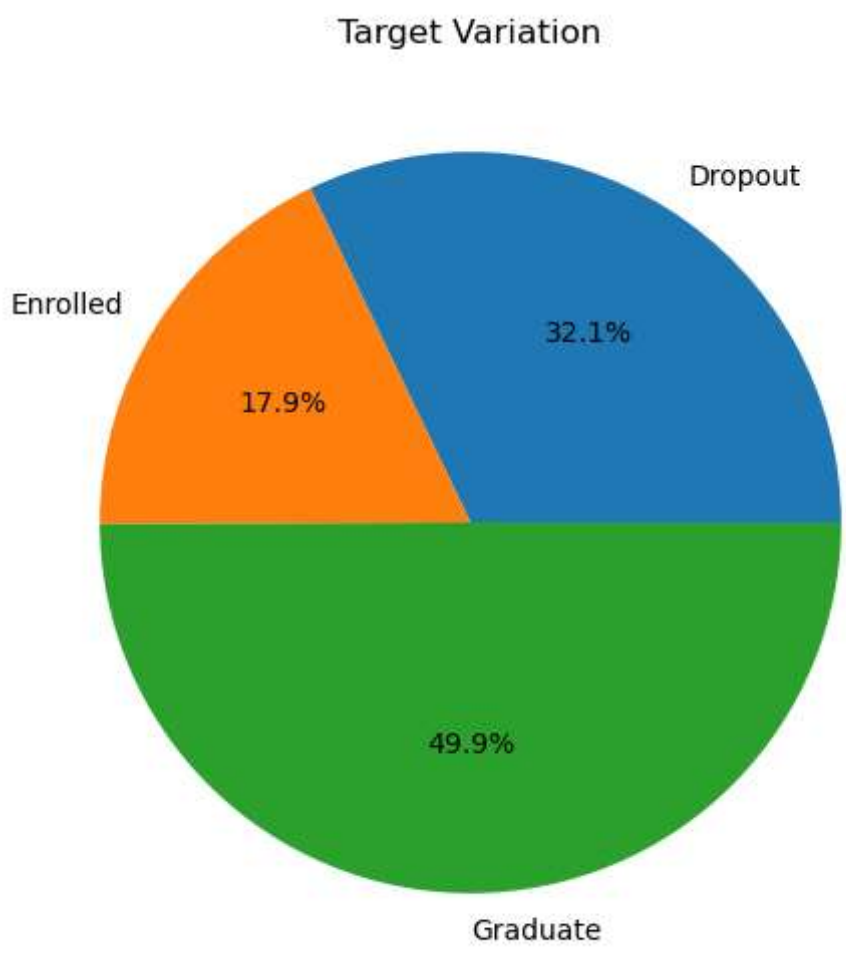
```
# Count the frequency of each category
category_counts = a_df.groupby(['Daytime/evening attendance', 'Target']).s

category_counts['Total'] = category_counts.sum(axis=1)
category_counts = category_counts.sort_values(by='Total', ascending=False)


# Plot the bar chart
plt.figure(figsize=(8, 6))
category_counts.plot(kind='bar',stacked ='True')

# Customize the chart
plt.title('Classification on the basis of Daytime/evening attendance')
plt.ylabel('Frequency')
plt.xlabel('Categories')

# Show the plot
plt.show()
```

```
<Figure size 800x600 with 0 Axes>
```



In [28]:

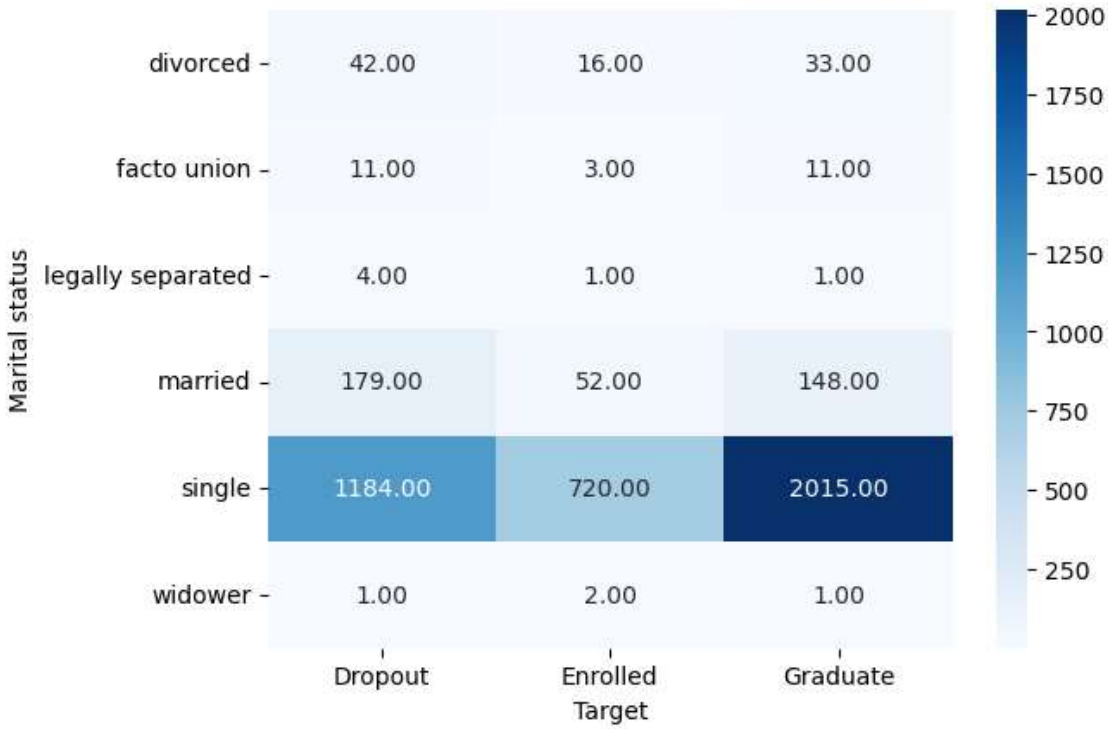
```
# Pie chart to see the variation in the target

#Checking the target variable
a_df.Target.value_counts(normalize=True)

# Group the DataFrame by 'target' and calculate the frequency
b_df = a_df.groupby('Target').size()

# Create a pie chart
plt.figure(figsize=(8, 6))
plt.pie(b_df, labels=b_df.index, autopct='%1.1f%%')

# Customize the pie chart
plt.title('Target Variation')

# Show the pie chart
plt.show()
```



In [29]:

```
# Heat Map table to show the variation based on the Marital Status

table = pd.crosstab(a_df['Marital status'], a_df['Target'])
sns.heatmap(table, annot=True, fmt='.2f', cmap='Blues')
```

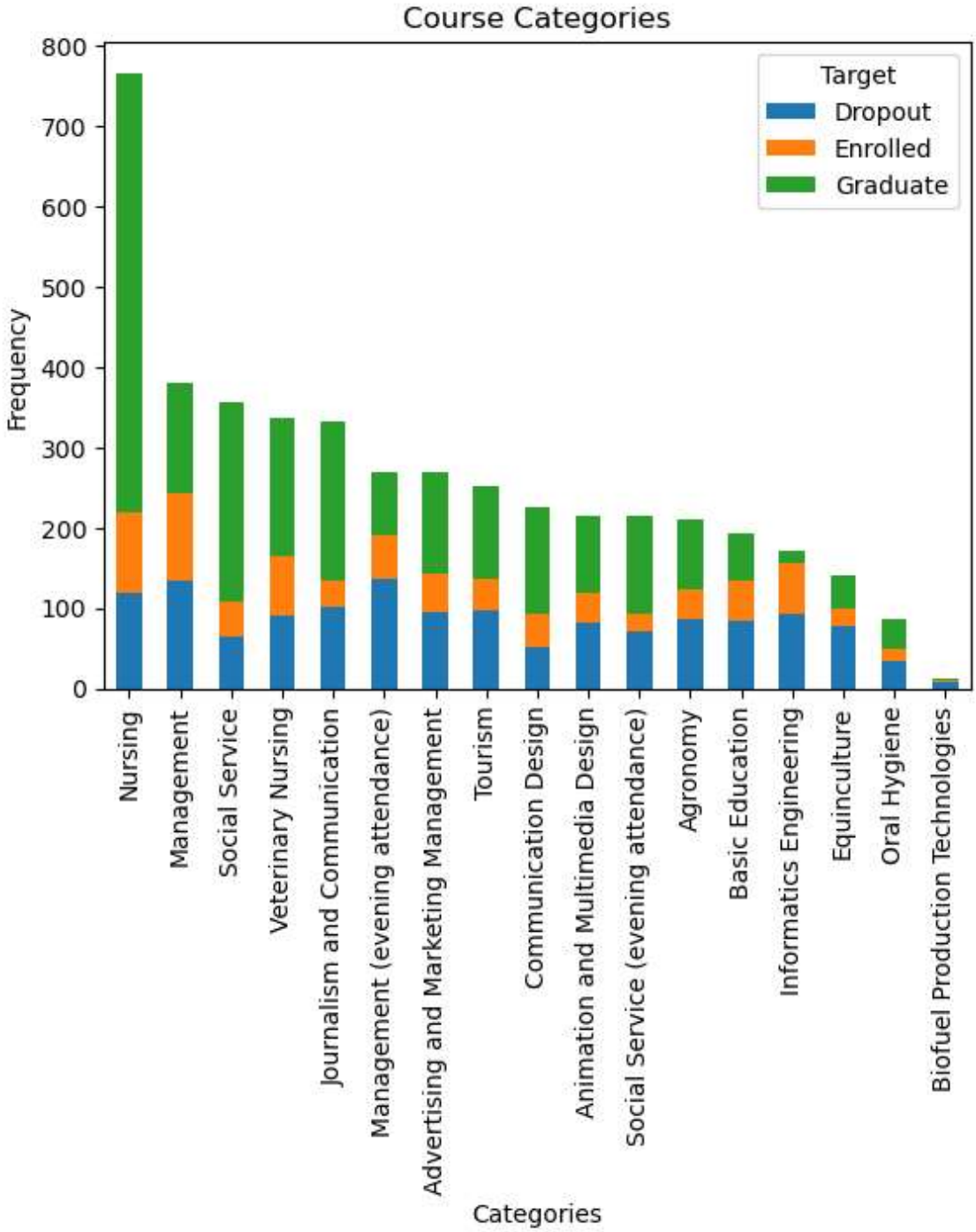
Out[29]: <Axes: xlabel='Target', ylabel='Marital status'>



In [30]:

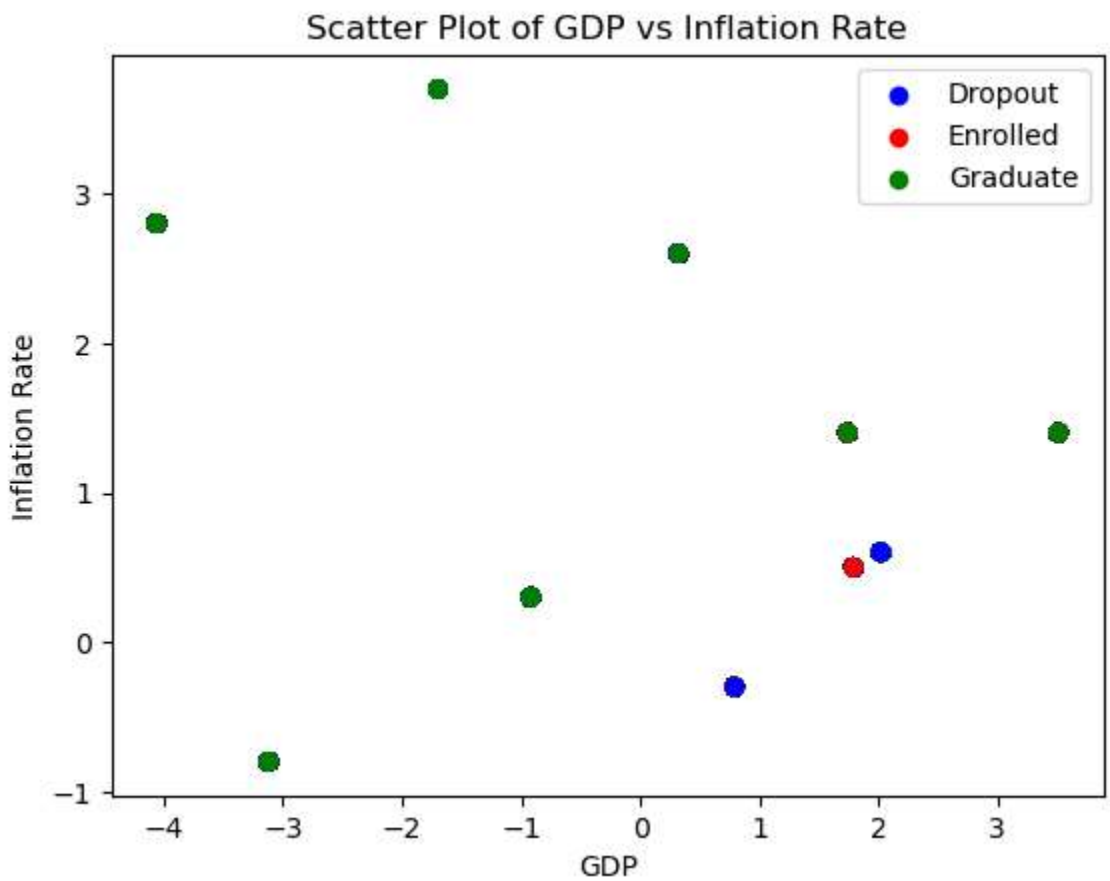
```
# Count the frequency of each category
category_counts = a_df.groupby(['Course', 'Target']).size().unstack()

category_counts['Total'] = category_counts.sum(axis=1)
category_counts = category_counts.sort_values(by='Total', ascending=False)


# Plot the bar chart
plt.figure(figsize=(8, 6))
category_counts.plot(kind='bar',stacked ='True')

# Customize the chart
plt.title('Course Categories')
plt.ylabel('Frequency')
plt.xlabel('Categories')

# Show the plot
plt.show()
```

```
<Figure size 800x600 with 0 Axes>
```


Course Categories
Target
Dropout
Enrolled
Graduate
Frequency
0
100
200
300
400
500
600
700
800
Nursing
Management
Social Service
Veterinary Nursing
Journalism and Communication
Management (evening attendance)
Advertising and Marketing Management
Tourism
Communication Design
Animation and Multimedia Design
Social Service (evening attendance)
Agronomy
Basic Education
Informatics Engineering
Equinculture
Oral Hygiene
Biofuel Production Technologies
Categories

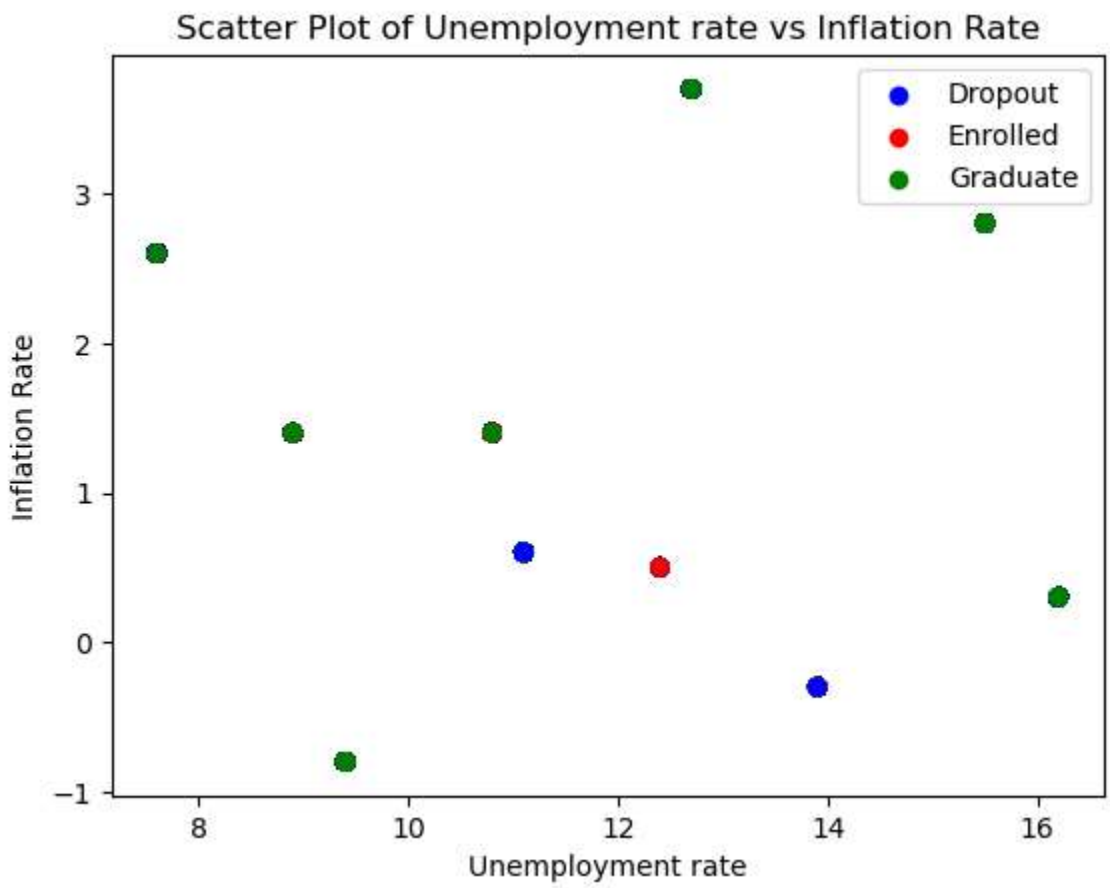
In [31]:

```
# Define colors for the target categories
colors = {'Dropout': 'blue', 'Enrolled': 'red', 'Graduate': 'green'}

# Create scatter plot
plt.scatter(a_df['GDP'], a_df['Inflation rate'], c=a_df['Target'].map(colo

# Set labels and title
plt.xlabel('GDP')
plt.ylabel('Inflation Rate')
plt.title('Scatter Plot of GDP vs Inflation Rate')

# Add color legend
for target, color in colors.items():
    plt.scatter([], [], c=color, label=target)

plt.legend()

# Show the plot
plt.show()
```



In [32]:

```
# Define colors for the target categories
colors = {'Dropout': 'blue', 'Enrolled': 'red', 'Graduate': 'green'}

# Create scatter plot
plt.scatter(a_df['Unemployment rate'], a_df['Inflation rate'], c=a_df['Tar

# Set labels and title
plt.xlabel('Unemployment rate')
plt.ylabel('Inflation Rate')
plt.title('Scatter Plot of Unemployment rate vs Inflation Rate')

# Add color legend
for target, color in colors.items():
    plt.scatter([], [], c=color, label=target)

plt.legend()

# Show the plot
plt.show()
```



Feature Engineering

In [33]:

```
values= {'Secondary Education - 12th Year of Schooling or Eq.':'Secondary
         "Higher Education - Bachelor's Degree": 'Graduate',
         'Higher Education - Degree': 'Graduate',
         "Higher Education - Master's":'Masters',
         "Higher Education - Doctorate":'Masters',
         'Frequency of Higher Education':'Graduate',
         '12th Year of Schooling - Not Completed':'Secondary Education',
         '11th Year of Schooling - Not Completed':'Secondary Education',
         '7th Year (Old)':'Secondary Education',
         'Other - 11th Year of Schooling':'Secondary Education',
         '10th Year of Schooling':'Secondary Education',
         'General commerce course':'Secondary Education',
         'Basic Education 3rd Cycle (9th/10th/11th Year) or Equiv.':'Secon
         'Technical-professional course':'Other',
         '7th year of schooling':'Secondary Education',
         '2nd cycle of the general high school course':'Secondary Educatio
         '9th Year of Schooling - Not Completed':'Secondary Education',
         '8th year of schooling':'Secondary Education',
         'Unknown':'Other',
         "Can't read or write":'Other',
         'Can read without having a 4th year of schooling':'Other',
         'Basic education 1st cycle (4th/5th year) or equiv.':'Secondary E
         'Basic Education 2nd Cycle (6th/7th/8th Year) or Equiv.':'Seconda
         'Technological specialization course':'Other',
         'Higher education - degree (1st cycle)':'Graduate',
         'Specialized higher studies course':'Other',
         'Professional higher technical course':'Other',
         'Higher Education - Master (2nd cycle)': 'Masters',
         'Higher Education - Doctorate (3rd cycle)':'Masters'}

a_df["Mother's qualification Category"] = a_df["Mother's qualification"].a

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade) Nacionality  \
0                           122.0  Portuguese
1                           160.0  Portuguese
2                           122.0  Portuguese
3                           122.0  Portuguese
4                           100.0  Portuguese

                             Mother's qualification  \
0  Basic Education 3rd Cycle (9th/10th/11th Year)...
1  Secondary Education - 12th Year of Schooling o...
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic Education 2nd Cycle (6th/7th/8th Year) o...
4  Basic education 1st cycle (4th/5th year) or eq...

                             Father's qualification  \
0                     Other - 11th Year of Schooling
1                          Higher Education - Degree
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic education 1st cycle (4th/5th year) or eq...
4  Basic Education 2nd Cycle (6th/7th/8th Year) o...

                             Mother's occupation  \
0  Personal Services, Security and Safety Workers
1                 Intermediate Level Technicians
2                             Unskilled Workers
3  Personal Services, Security and Safety Workers
4                             Unskilled Workers

                             Father's occupation  ...  Scholarship holde
r  \
0                             Unskilled Workers  ...
0
1  Intermediate Level Technicians and Professions  ...
0
2                             Unskilled Workers  ...
0
3  Intermediate Level Technicians and Professions  ...
0
4                             Unskilled Workers  ...
0

   Age at enrollment  International  Curricular units 1st sem (grade)  \
0                 20              0                          0.000000
```

```
1                 19             0                        14.000000
2                 19             0                         0.000000
3                 20             0                        13.428571
4                 45             0                        12.333333

  Curricular units 2nd sem (grade)  Unemployment rate  Inflation rate   G
DP  \
0                        0.000000               10.8             1.4  1.
74
1                       13.666667               13.9            -0.3  0.
79
2                        0.000000               10.8             1.4  1.
74
3                       12.400000                9.4            -0.8 -3.
12
4                       13.000000               13.9            -0.3  0.
79

     Target  Mother's qualification Category
0   Dropout              Secondary Education
1  Graduate              Secondary Education
2   Dropout              Secondary Education
3  Graduate              Secondary Education
4  Graduate              Secondary Education

[5 rows x 25 columns]
```

In [34]:

```
values= {'Secondary Education - 12th Year of Schooling or Eq.':'Secondary
         '12th Year of Schooling - Not Completed':'Secondary Education',
         '11th Year of Schooling - Not Completed':'Secondary Education',
         '7th Year (Old)':'Secondary Education',
         'Other - 11th Year of Schooling':'Secondary Education',
         '2nd year complementary high school course':'Secondary Education'
         '10th Year of Schooling':'Secondary Education',
         'Basic Education 3rd Cycle (9th/10th/11th Year) or Equiv.':'Secon
         'Complementary High School Course':'Secondary Education',
         'Technical-professional course':'Secondary Education',
         'Complementary High School Course - not concluded':'Secondary Edu
         '7th year of schooling':'Secondary Education',
         '2nd cycle of the general high school course':'Secondary Educatio
         '9th Year of Schooling - Not Completed':'Secondary Education',
         '8th year of schooling':'Secondary Education',
         'Basic education 1st cycle (4th/5th year) or equiv.':'Secondary E
         'Basic Education 2nd Cycle (6th/7th/8th Year) or Equiv.':'Seconda
         "Higher Education - Bachelor's Degree": 'Graduate',
         'Higher Education - Degree': 'Graduate',
         "Higher Education - Master's": 'Masters',
         'Higher Education - Doctorate': 'Masters',
         'Frequency of Higher Education': 'Graduate',
         'Higher education - degree (1st cycle)': 'Graduate',
         'Higher Education - Master (2nd cycle)': 'Masters',
         'Higher Education - Doctorate (3rd cycle)': 'Masters',
         'General commerce course':'Other',
         'General Course of Administration and Commerce':'Other',
         'Supplementary Accounting and Administration':'Other',
         "Can't read or write":'Other',
         'Can read without having a 4th year of schooling':'Other',
         'Technological specialization course':'Other',
         'Specialized higher studies course':'Other',
         'Professional higher technical course':'Other',
         'Unknown':'Other'}

a_df["Father's qualification Category"] = a_df["Father's qualification"].a

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade) Nacionality  \
0                           122.0  Portuguese
1                           160.0  Portuguese
2                           122.0  Portuguese
3                           122.0  Portuguese
4                           100.0  Portuguese

                             Mother's qualification  \
0  Basic Education 3rd Cycle (9th/10th/11th Year)...
1  Secondary Education - 12th Year of Schooling o...
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic Education 2nd Cycle (6th/7th/8th Year) o...
4  Basic education 1st cycle (4th/5th year) or eq...

                             Father's qualification  \
0                     Other - 11th Year of Schooling
1                          Higher Education - Degree
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic education 1st cycle (4th/5th year) or eq...
4  Basic Education 2nd Cycle (6th/7th/8th Year) o...

                             Mother's occupation  \
0  Personal Services, Security and Safety Workers
1                 Intermediate Level Technicians
2                             Unskilled Workers
3  Personal Services, Security and Safety Workers
4                             Unskilled Workers

                             Father's occupation  ...  Age at enrollment
\
0                             Unskilled Workers  ...                 20
1  Intermediate Level Technicians and Professions  ...                 19
2                             Unskilled Workers  ...                 19
3  Intermediate Level Technicians and Professions  ...                 20
4                             Unskilled Workers  ...                 45

   International  Curricular units 1st sem (grade)  \
0              0                          0.000000
1              0                         14.000000
2              0                          0.000000
3              0                         13.428571
4              0                         12.333333
```

```
   Curricular units 2nd sem (grade) Unemployment rate  Inflation rate   G
DP  \
0                          0.000000              10.8             1.4  1.
74
1                         13.666667              13.9            -0.3  0.
79
2                          0.000000              10.8             1.4  1.
74
3                         12.400000               9.4            -0.8 -3.
12
4                         13.000000              13.9            -0.3  0.
79

     Target  Mother's qualification Category  Father's qualification Cate
gory
0   Dropout              Secondary Education              Secondary Educa
tion
1  Graduate              Secondary Education                        Grad
uate
2   Dropout              Secondary Education              Secondary Educa
tion
3  Graduate              Secondary Education              Secondary Educa
tion
4  Graduate              Secondary Education              Secondary Educa
tion

[5 rows x 26 columns]
```

In [35]:

```
values= {'Secondary education':'Secondary Education',
         "Higher education - bachelor's degree":'Graduate',
         'Higher education - degree':'Graduate',
         "Higher education - master's":'Masters',
         'Higher education - doctorate':'Masters',
         'Frequency of higher education':'Graduate',
         '12th year of schooling - not completed':'Secondary Education',
         '11th year of schooling - not completed':'Secondary Education',
         'Other - 11th year of schooling':'Secondary Education',
         '10th year of schooling':'Secondary Education',
         '10th year of schooling - not completed':'Secondary Education',
         'Basic education 3rd cycle (9th/10th/11th year) or equiv.':'Secon
         'Basic education 2nd cycle (6th/7th/8th year) or equiv.':'Seconda
         'Technological specialization course':'Other',
         'Higher education - degree (1st cycle)':'Graduate',
         'Professional higher technical course':'Other',
         'Higher education - master (2nd cycle)':'Masters'}

a_df["Previous qualification Category"] = a_df["Previous qualification"].a

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade) Nacionality  \
0                           122.0  Portuguese
1                           160.0  Portuguese
2                           122.0  Portuguese
3                           122.0  Portuguese
4                           100.0  Portuguese

                             Mother's qualification  \
0  Basic Education 3rd Cycle (9th/10th/11th Year)...
1  Secondary Education - 12th Year of Schooling o...
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic Education 2nd Cycle (6th/7th/8th Year) o...
4  Basic education 1st cycle (4th/5th year) or eq...

                             Father's qualification  \
0                     Other - 11th Year of Schooling
1                          Higher Education - Degree
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic education 1st cycle (4th/5th year) or eq...
4  Basic Education 2nd Cycle (6th/7th/8th Year) o...

                             Mother's occupation  \
0  Personal Services, Security and Safety Workers
1                 Intermediate Level Technicians
2                               Unskilled Workers
3  Personal Services, Security and Safety Workers
4                               Unskilled Workers

                             Father's occupation  ...  International  \
0                               Unskilled Workers  ...              0
1  Intermediate Level Technicians and Professions  ...              0
2                               Unskilled Workers  ...              0
3  Intermediate Level Technicians and Professions  ...              0
4                               Unskilled Workers  ...              0

   Curricular units 1st sem (grade)  Curricular units 2nd sem (grade)  \
0                          0.000000                          0.000000
1                         14.000000                         13.666667
2                          0.000000                          0.000000
3                         13.428571                         12.400000
4                         12.333333                         13.000000

   Unemployment rate Inflation rate   GDP    Target  \
```

```
0               10.8            1.4  1.74   Dropout
1               13.9           -0.3  0.79  Graduate
2               10.8            1.4  1.74   Dropout
3                9.4           -0.8 -3.12  Graduate
4               13.9           -0.3  0.79  Graduate

   Mother's qualification Category  Father's qualification Category  \
0              Secondary Education              Secondary Education
1              Secondary Education                          Graduate
2              Secondary Education              Secondary Education
3              Secondary Education              Secondary Education
4              Secondary Education              Secondary Education

   Previous qualification Category
0              Secondary Education
1              Secondary Education
2              Secondary Education
3              Secondary Education
4              Secondary Education

[5 rows x 27 columns]
```

In [36]:

```
values= {'Student': 'Education',
         'Representatives of the Legislative Power and Executive Bodies' :
         'Intellectual and Scientific Specialists' : 'Intellectual and Sci
         'Intermediate Level Technicians' : 'Technical and Intermediate Le
         'Administrative staff' : 'Administrative and Office Support',
         'Personal Services, Security and Safety Workers' :'Skilled Worker
         'Farmers and Skilled Workers in Agriculture, Fisheries and Forest
         'Skilled Workers in Industry, Construction and Craftsmen' : 'Skil
         'Installation and Machine Operators and Assembly Workers': 'Skill
         'Unskilled Workers' : 'Unskilled Workers',
         'Armed Forces Professions' : 'Government and Public Services',
         'Other Situation' : 'Other and Unknown Situations',
         'Unknown' : 'Other and Unknown Situations',
         'Health professionals' : 'Intellectual and Scientific Professions
         'teachers':'Intellectual and Scientific Professions',
         'Specialists in ICT' : 'Intellectual and Scientific Professions',
         'Intermediate level science and engineering technicians and profe
         'Intermediate level Technicians and Health professionals' : 'Tech
         'Intermediate level technicians from legal, social, sports, cultu
         'Office workers, secretaries and data processing operators' : 'Ad
         'Data, accounting, statistical, financial services and registry-r
         'Other administrative support staff' : 'Administrative and Office
         'personal service workers' : 'Skilled Workers',
         'sellers' : 'Unskilled Workers',
         'Personal care workers' : 'Skilled Workers',
         'Skilled construction workers except electricians' : 'Skilled Wor
         'Skilled workers in printing, precision instrument manufacturing,
         'Workers in food processing, woodworking, clothing and other indu
         'Cleaning workers' : 'Unskilled Workers',
         'Unskilled workers in agriculture, animal production, fisheries a
         'Unskilled workers in extractive industry, construction, manufact
         'Meal preparation assistants' : 'Unskilled Workers'}

a_df["Mother's occupation_category"] = a_df["Mother's occupation"].apply(l

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade) Nacionality  \
0                           122.0  Portuguese
1                           160.0  Portuguese
2                           122.0  Portuguese
3                           122.0  Portuguese
4                           100.0  Portuguese

                             Mother's qualification  \
0  Basic Education 3rd Cycle (9th/10th/11th Year)...
1  Secondary Education - 12th Year of Schooling o...
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic Education 2nd Cycle (6th/7th/8th Year) o...
4  Basic education 1st cycle (4th/5th year) or eq...

                             Father's qualification  \
0                     Other - 11th Year of Schooling
1                          Higher Education - Degree
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic education 1st cycle (4th/5th year) or eq...
4  Basic Education 2nd Cycle (6th/7th/8th Year) o...

                             Mother's occupation  \
0  Personal Services, Security and Safety Workers
1                 Intermediate Level Technicians
2                              Unskilled Workers
3  Personal Services, Security and Safety Workers
4                              Unskilled Workers

                             Father's occupation  ...  \
0                              Unskilled Workers  ...
1  Intermediate Level Technicians and Professions  ...
2                              Unskilled Workers  ...
3  Intermediate Level Technicians and Professions  ...
4                              Unskilled Workers  ...

   Curricular units 1st sem (grade)  Curricular units 2nd sem (grade)  \
0                          0.000000                          0.000000
1                         14.000000                         13.666667
2                          0.000000                          0.000000
3                         13.428571                         12.400000
4                         12.333333                         13.000000

   Unemployment rate  Inflation rate   GDP    Target  \
```

```
0               10.8             1.4  1.74   Dropout
1               13.9            -0.3  0.79  Graduate
2               10.8             1.4  1.74   Dropout
3                9.4            -0.8 -3.12  Graduate
4               13.9            -0.3  0.79  Graduate

   Mother's qualification Category  Father's qualification Category  \
0              Secondary Education              Secondary Education
1              Secondary Education                          Graduate
2              Secondary Education              Secondary Education
3              Secondary Education              Secondary Education
4              Secondary Education              Secondary Education

   Previous qualification Category  \
0              Secondary Education
1              Secondary Education
2              Secondary Education
3              Secondary Education
4              Secondary Education

                   Mother's occupation_category
0                              Skilled Workers
1  Technical and Intermediate Level Professions
2                            Unskilled Workers
3                              Skilled Workers
4                            Unskilled Workers

[5 rows x 28 columns]
```

In [37]:

```
t' : 'Education',
entatives of the Legislative Power and Executive Bodies' : 'Government and
ectual and Scientific Specialists' : 'Intellectual and Scientific Professic
ediate Level Technicians and Professions' : 'Intellectual and Scientific Pr
strative staff' : 'Administrative and Office Support',
al Services, Security and Safety Workers/Sellers' : 'Skilled Workers',
s and Skilled Workers in Agriculture, Fisheries and Forestry' : 'Skilled Wo
d Workers in Industry, Construction and Craftsmen' : 'Skilled Workers',
lation and Machine Operators and Assembly Workers' : 'Skilled Workers',
led Workers' : 'Unskilled Workers',
Forces Professions' : 'Government and Public Services',
Situation' : 'Other and Unknown Situations',
n' : 'Other and Unknown Situations',
Forces Officers' : 'Government and Public Services',
Forces Sergeants' : 'Government and Public Services',
Armed Forces personnel' : 'Government and Public Services',
ors of administrative and commercial services' : 'Administrative and Office
 catering, trade and other services directors' : 'Administrative and Office
lists in the physical sciences, mathematics, engineering and related techni
 professionals' : 'Intellectual and Scientific Professions',
rs' : 'Intellectual and Scientific Professions',
lists in finance, accounting, administrative organization, public and comme
ediate level science and engineering technicians and professions' : 'Techni
ediate level Technicians and Health professionals' : 'Technical and Interme
ediate level technicians from legal, social, sports, cultural and similar s
ation and communication technology technicians' : 'Technical and Intermedia
 workers/secretaries and data processing operators' : 'Administrative and C
accounting, statistical, financial services and registry-related operators'
administrative support staff' : 'Administrative and Office Support',
al service workers' : 'Skilled Workers',
s' : 'Unskilled Workers',
al care workers' : 'Skilled Workers',
tion and security services personnel' : 'Skilled Workers',
-oriented farmers and skilled agricultural and animal production workers' :
s, livestock keepers, fishermen, hunters and gatherers, subsistence' : 'Uns
d construction workers except electricians' : 'Skilled Workers',
d workers in metallurgy, metalworking' : 'Skilled Workers',
d workers in electricity and electronics' : 'Skilled Workers',
s in food processing, woodworking, clothing and other industries and crafts
plant and machine operators' : 'Unskilled Workers',
ly workers' : 'Unskilled Workers',
e drivers and mobile equipment operators' : 'Skilled Workers',
led workers in agriculture, animal production, fisheries and forestry' : 'U
led workers in extractive industry, construction, manufacturing and transpo
reparation assistants' : 'Unskilled Workers',
 vendors (except food) and street service providers' : 'Unskilled Workers']

ccupation_category"] = a_df["Father's occupation"].apply(lambda x: values[x

ted DataFrame
))
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade) Nacionality  \
0                           122.0  Portuguese
1                           160.0  Portuguese
2                           122.0  Portuguese
3                           122.0  Portuguese
4                           100.0  Portuguese

                             Mother's qualification  \
0  Basic Education 3rd Cycle (9th/10th/11th Year)...
1  Secondary Education - 12th Year of Schooling o...
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic Education 2nd Cycle (6th/7th/8th Year) o...
4  Basic education 1st cycle (4th/5th year) or eq...

                             Father's qualification  \
0                     Other - 11th Year of Schooling
1                          Higher Education - Degree
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic education 1st cycle (4th/5th year) or eq...
4  Basic Education 2nd Cycle (6th/7th/8th Year) o...

                             Mother's occupation  \
0  Personal Services, Security and Safety Workers
1                 Intermediate Level Technicians
2                              Unskilled Workers
3  Personal Services, Security and Safety Workers
4                              Unskilled Workers

                             Father's occupation  ...  \
0                              Unskilled Workers  ...
1  Intermediate Level Technicians and Professions  ...
2                              Unskilled Workers  ...
3  Intermediate Level Technicians and Professions  ...
4                              Unskilled Workers  ...

   Curricular units 2nd sem (grade)  Unemployment rate  Inflation rate
GDP  \
0                          0.000000               10.8             1.4
1.74
1                         13.666667               13.9            -0.3
0.79
2                          0.000000               10.8             1.4
1.74
```

```
3                        12.400000               9.4            -0.8 -
3.12
4                        13.000000              13.9            -0.3
0.79

     Target  Mother's qualification Category  Father's qualification Cate
gory  \
0   Dropout              Secondary Education              Secondary Educa
tion
1  Graduate              Secondary Education                        Grad
uate
2   Dropout              Secondary Education              Secondary Educa
tion
3  Graduate              Secondary Education              Secondary Educa
tion
4  Graduate              Secondary Education              Secondary Educa
tion

   Previous qualification Category  \
0              Secondary Education
1              Secondary Education
2              Secondary Education
3              Secondary Education
4              Secondary Education

                   Mother's occupation_category  \
0                               Skilled Workers
1  Technical and Intermediate Level Professions
2                             Unskilled Workers
3                               Skilled Workers
4                             Unskilled Workers

              Father's occupation_category
0                       Unskilled Workers
1  Intellectual and Scientific Professions
2                       Unskilled Workers
3  Intellectual and Scientific Professions
4                       Unskilled Workers

[5 rows x 29 columns]
```

In [38]:

```
values= {'Biofuel Production Technologies' : 'Engineering and Technology',
         'Animation and Multimedia Design' : 'Design and Multimedia',
         'Social Service (evening attendance)' : 'Social Service',
         'Agronomy' : 'Agriculture',
         'Communication Design' : 'Design and Multimedia',
         'Veterinary Nursing' : 'Healthcare and Medical',
         'Informatics Engineering' : 'Engineering and Technology',
         'Equinculture' : 'Agriculture',
         'Management' : 'Business and Management',
         'Social Service' : 'Social Service',
         'Tourism' : 'Tourism and Hospitality',
         'Nursing' : 'Healthcare and Medical',
         'Oral Hygiene' : 'Healthcare and Medical',
         'Advertising and Marketing Management' : 'Business and Management
         'Journalism and Communication' : 'Design and Multimedia',
         'Basic Education' : 'Education',
         'Management (evening attendance)' : 'Business and Management'}

a_df["Course_category"] = a_df["Course"].apply(lambda x: values[x] if x in

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade) Nacionality  \
0                           122.0  Portuguese
1                           160.0  Portuguese
2                           122.0  Portuguese
3                           122.0  Portuguese
4                           100.0  Portuguese

                             Mother's qualification  \
0  Basic Education 3rd Cycle (9th/10th/11th Year)...
1  Secondary Education - 12th Year of Schooling o...
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic Education 2nd Cycle (6th/7th/8th Year) o...
4  Basic education 1st cycle (4th/5th year) or eq...

                             Father's qualification  \
0                     Other - 11th Year of Schooling
1                          Higher Education - Degree
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic education 1st cycle (4th/5th year) or eq...
4  Basic Education 2nd Cycle (6th/7th/8th Year) o...

                             Mother's occupation  \
0  Personal Services, Security and Safety Workers
1                 Intermediate Level Technicians
2                             Unskilled Workers
3  Personal Services, Security and Safety Workers
4                             Unskilled Workers

                             Father's occupation  ...  Unemployment rate
\
0                             Unskilled Workers  ...               10.8
1  Intermediate Level Technicians and Professions  ...               13.9
2                             Unskilled Workers  ...               10.8
3  Intermediate Level Technicians and Professions  ...                9.4
4                             Unskilled Workers  ...               13.9

   Inflation rate   GDP    Target Mother's qualification Category  \
0             1.4  1.74   Dropout             Secondary Education
1            -0.3  0.79  Graduate             Secondary Education
2             1.4  1.74   Dropout             Secondary Education
3            -0.8 -3.12  Graduate             Secondary Education
4            -0.3  0.79  Graduate             Secondary Education
```

```
   Father's qualification Category  Previous qualification Category  \
0              Secondary Education              Secondary Education
1                         Graduate              Secondary Education
2              Secondary Education              Secondary Education
3              Secondary Education              Secondary Education
4              Secondary Education              Secondary Education

                   Mother's occupation_category  \
0                               Skilled Workers
1  Technical and Intermediate Level Professions
2                             Unskilled Workers
3                               Skilled Workers
4                             Unskilled Workers

             Father's occupation_category          Course_category
0                       Unskilled Workers    Design and Multimedia
1  Intellectual and Scientific Professions  Tourism and Hospitality
2                       Unskilled Workers    Design and Multimedia
3  Intellectual and Scientific Professions    Design and Multimedia
4                       Unskilled Workers           Social Service

[5 rows x 30 columns]
```

In [39]:

```
values= {'Enrolled': 'Non-Dropout',
         'Graduate' : 'Non-Dropout',
         'Dropout' : 'Dropout'}

a_df["Target"] = a_df["Target"].apply(lambda x: values[x] if x in values e

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade) Nacionality  \
0                           122.0  Portuguese
1                           160.0  Portuguese
2                           122.0  Portuguese
3                           122.0  Portuguese
4                           100.0  Portuguese

                             Mother's qualification  \
0  Basic Education 3rd Cycle (9th/10th/11th Year)...
1  Secondary Education - 12th Year of Schooling o...
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic Education 2nd Cycle (6th/7th/8th Year) o...
4  Basic education 1st cycle (4th/5th year) or eq...

                             Father's qualification  \
0                     Other - 11th Year of Schooling
1                          Higher Education - Degree
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic education 1st cycle (4th/5th year) or eq...
4  Basic Education 2nd Cycle (6th/7th/8th Year) o...

                             Mother's occupation  \
0  Personal Services, Security and Safety Workers
1                 Intermediate Level Technicians
2                              Unskilled Workers
3  Personal Services, Security and Safety Workers
4                              Unskilled Workers

                             Father's occupation  ...  Unemployment rate
\
0                              Unskilled Workers  ...               10.8
1  Intermediate Level Technicians and Professions  ...               13.9
2                              Unskilled Workers  ...               10.8
3  Intermediate Level Technicians and Professions  ...                9.4
4                              Unskilled Workers  ...               13.9

   Inflation rate   GDP       Target Mother's qualification Category  \
0             1.4  1.74      Dropout             Secondary Education
1            -0.3  0.79  Non-Dropout             Secondary Education
2             1.4  1.74      Dropout             Secondary Education
3            -0.8 -3.12  Non-Dropout             Secondary Education
4            -0.3  0.79  Non-Dropout             Secondary Education
```

```
   Father's qualification Category  Previous qualification Category  \
0              Secondary Education              Secondary Education
1                        Graduate              Secondary Education
2              Secondary Education              Secondary Education
3              Secondary Education              Secondary Education
4              Secondary Education              Secondary Education

                  Mother's occupation_category  \
0                               Skilled Workers
1  Technical and Intermediate Level Professions
2                             Unskilled Workers
3                               Skilled Workers
4                             Unskilled Workers

             Father's occupation_category          Course_category
0                       Unskilled Workers    Design and Multimedia
1  Intellectual and Scientific Professions  Tourism and Hospitality
2                       Unskilled Workers    Design and Multimedia
3  Intellectual and Scientific Professions    Design and Multimedia
4                       Unskilled Workers           Social Service

[5 rows x 30 columns]
```

In [40]:

```
#Remove rows where age is greater than 70 years
a_df = a_df[a_df['Age at enrollment'] <= 70]
a_df.head()
```

Out[40]:

	Marital status	Course	Daytime/evening attendance	Previous qualification	Previous qualification (grade)	Nacionality	Moth qualifica
0	single	Animation and Multimedia Design	1	Secondary education	122.0	Portuguese	E Educ 3rd C (9th/10th Ye
1	single	Tourism	1	Secondary education	160.0	Portuguese	Secon Educat 12th Ye Schoolin
2	single	Communication Design	1	Secondary education	122.0	Portuguese	E educatio cycle (4t year) or
3	single	Journalism and Communication	1	Secondary education	122.0	Portuguese	E Educ 2nd C (6th/7t Year
4	married	Social Service (evening attendance)	0	Secondary education	100.0	Portuguese	E educatio cycle (4t year) or

5 rows × 30 columns

In [41]:

```
# To define the age ranges and corresponding categories
bins = [0, 18, 65, float('inf')]
categories = ['Child', 'Adult', 'Senior']

# Create a new column "age_category" based on the age ranges and categorie
a_df['Age at enrollment'] = pd.cut(a_df['Age at enrollment'], bins=bins, l

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status                                Course  \
0         single      Animation and Multimedia Design
1         single                              Tourism
2         single                 Communication Design
3         single         Journalism and Communication
4        married  Social Service (evening attendance)

   Daytime/evening attendance Previous qualification  \
0                           1    Secondary education
1                           1    Secondary education
2                           1    Secondary education
3                           1    Secondary education
4                           0    Secondary education

   Previous qualification (grade) Nacionality  \
0                           122.0  Portuguese
1                           160.0  Portuguese
2                           122.0  Portuguese
3                           122.0  Portuguese
4                           100.0  Portuguese

                             Mother's qualification  \
0  Basic Education 3rd Cycle (9th/10th/11th Year)...
1  Secondary Education - 12th Year of Schooling o...
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic Education 2nd Cycle (6th/7th/8th Year) o...
4  Basic education 1st cycle (4th/5th year) or eq...

                             Father's qualification  \
0                     Other - 11th Year of Schooling
1                          Higher Education - Degree
2  Basic education 1st cycle (4th/5th year) or eq...
3  Basic education 1st cycle (4th/5th year) or eq...
4  Basic Education 2nd Cycle (6th/7th/8th Year) o...

                             Mother's occupation  \
0  Personal Services, Security and Safety Workers
1                 Intermediate Level Technicians
2                             Unskilled Workers
3  Personal Services, Security and Safety Workers
4                             Unskilled Workers

                             Father's occupation  ...  Unemployment rate
\
0                             Unskilled Workers  ...               10.8
1  Intermediate Level Technicians and Professions  ...               13.9
2                             Unskilled Workers  ...               10.8
3  Intermediate Level Technicians and Professions  ...                9.4
4                             Unskilled Workers  ...               13.9

   Inflation rate   GDP       Target Mother's qualification Category  \
0             1.4  1.74      Dropout             Secondary Education
1            -0.3  0.79  Non-Dropout             Secondary Education
2             1.4  1.74      Dropout             Secondary Education
3            -0.8 -3.12  Non-Dropout             Secondary Education
4            -0.3  0.79  Non-Dropout             Secondary Education
```

```
   Father's qualification Category Previous qualification Category  \
0              Secondary Education              Secondary Education
1                         Graduate              Secondary Education
2              Secondary Education              Secondary Education
3              Secondary Education              Secondary Education
4              Secondary Education              Secondary Education

                   Mother's occupation_category  \
0                               Skilled Workers
1  Technical and Intermediate Level Professions
2                             Unskilled Workers
3                               Skilled Workers
4                             Unskilled Workers

              Father's occupation_category          Course_category
0                        Unskilled Workers    Design and Multimedia
1  Intellectual and Scientific Professions  Tourism and Hospitality
2                        Unskilled Workers    Design and Multimedia
3  Intellectual and Scientific Professions    Design and Multimedia
4                        Unskilled Workers           Social Service

[5 rows x 30 columns]
```

In [42]:

```
#Drop unwanted columns:
a_df = a_df.drop(columns=['International','Nacionality','Previous qualific
                          "Mother's qualification","Father's qualification
                         "Father's occupation", "Mother's occupation", "GD
a_df.head()
```

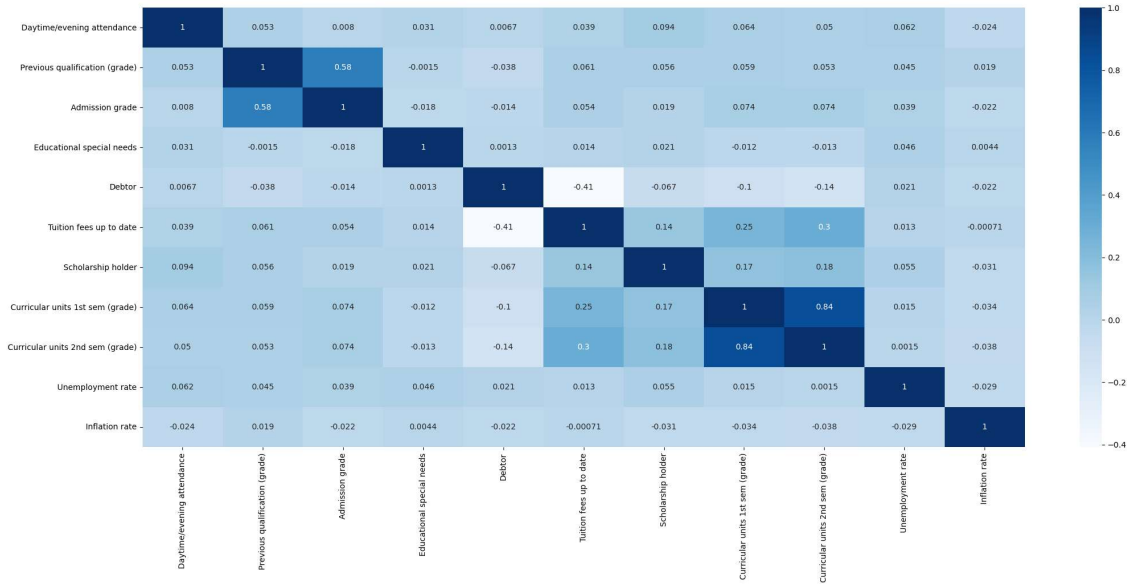
Out[42]:

	Marital status	Daytime/evening attendance	Previous qualification (grade)	Admission grade	Educational special needs	Debtor	Tuition fees up to date	Gender
0	single	1	122.0	127.3	0	0	1	male
1	single	1	160.0	142.5	0	0	0	male
2	single	1	122.0	124.8	0	0	0	male
3	single	1	122.0	119.6	0	0	1	female
4	married	0	100.0	141.5	0	0	1	female

5 rows × 21 columns

In [43]:

```
plt.figure(figsize=(25,10))
cor = a_df.corr()
sns.heatmap(cor, annot=True, cmap=plt.cm.Blues)
plt.show()
```



In [44]:

```
# Applying the lambda function to the 'target' column to convert 'Yes' to
a_df['Target'] = a_df['Target'].apply(lambda x: 1 if x == 'Dropout' else 0

# Print the updated DataFrame
print(a_df.head())
```

```
  Marital status  Daytime/evening attendance  Previous qualification (gra
de)  \
0         single                           1                           12
2.0
1         single                           1                           16
0.0
2         single                           1                           12
2.0
3         single                           1                           12
2.0
4        married                           0                           10
0.0

   Admission grade  Educational special needs  Debtor  \
0            127.3                          0       0
1            142.5                          0       0
2            124.8                          0       0
3            119.6                          0       0
4            141.5                          0       0

   Tuition fees up to date  Gender  Scholarship holder Age at enrollment
...  \
0                        1    male                   0             Adult
...
1                        0    male                   0             Adult
...
2                        0    male                   0             Adult
...
3                        1  female                   0             Adult
...
4                        1  female                   0             Adult
...

   Curricular units 2nd sem (grade)  Unemployment rate  Inflation rate  \
0                          0.000000               10.8             1.4
1                         13.666667               13.9            -0.3
2                          0.000000               10.8             1.4
3                         12.400000                9.4            -0.8
4                         13.000000               13.9            -0.3

   Target  Mother's qualification Category Father's qualification Categor
y  \
0       1              Secondary Education             Secondary Educatio
n
1       0              Secondary Education                        Graduat
e
2       1              Secondary Education             Secondary Educatio
n
3       0              Secondary Education             Secondary Educatio
n
4       0              Secondary Education             Secondary Educatio
n

  Previous qualification Category  \
0             Secondary Education
1             Secondary Education
2             Secondary Education
```

```
3             Secondary Education
4             Secondary Education

                  Mother's occupation_category  \
0                               Skilled Workers
1  Technical and Intermediate Level Professions
2                             Unskilled Workers
3                               Skilled Workers
4                             Unskilled Workers

              Father's occupation_category          Course_category
0                        Unskilled Workers    Design and Multimedia
1  Intellectual and Scientific Professions  Tourism and Hospitality
2                        Unskilled Workers    Design and Multimedia
3  Intellectual and Scientific Professions    Design and Multimedia
4                        Unskilled Workers           Social Service

[5 rows x 21 columns]
```

In [45]:

```
#pip install category_encoders

# Initialize the TargetEncoder
target_enc = TargetEncoder()

# Fit and transform the 'Course_category' column using the 'Target' column
a_df['Encoded_Course_category'] = target_enc.fit_transform(X=a_df['Course_
a_df["Encoded_Mother's occupation_category"] = target_enc.fit_transform(X=
a_df["Encoded_Father's occupation_category"] = target_enc.fit_transform(X=

# Display the DataFrame
a_df.head()
```

Out[45]:

	Marital status	Daytime/evening attendance	Previous qualification (grade)	Admission grade	Educational special needs	Debtor	Tuition fees up to date	Gender
0	single	1	122.0	127.3	0	0	1	male
1	single	1	160.0	142.5	0	0	0	male
2	single	1	122.0	124.8	0	0	0	male
3	single	1	122.0	119.6	0	0	1	female
4	married	0	100.0	141.5	0	0	1	female

5 rows × 24 columns

In [46]:

```
# Select the columns to one-hot encode
columns_to_encode = ['Gender', 'Marital status', "Mother's qualification C
                     "Father's qualification Category", 'Previous qualific

# One-hot encoding the categorical variables
encoder = OneHotEncoder(sparse=False)
categorical_encoded = pd.DataFrame(encoder.fit_transform(a_df[columns_to_e

# Concatenate the encoded columns with the original DataFrame 'a_df'
a_df_encoded = pd.concat([a_df, categorical_encoded], axis=1)

# Display the result
a_df_encoded.head()
```

Out[46]:

	Marital status	Daytime/evening attendance	Previous qualification (grade)	Admission grade	Educational special needs	Debtor	Tuition fees up to date	Gender
0	single	1	122.0	127.3	0	0	1	male
1	single	1	160.0	142.5	0	0	0	male
2	single	1	122.0	124.8	0	0	0	male
3	single	1	122.0	119.6	0	0	1	female
4	married	0	100.0	141.5	0	0	1	female

5 rows × 47 columns

In [47]:

```
#Drop unwanted columns:
a_df_encoded = a_df_encoded.drop(columns=['Gender', 'Marital status', "Mot
                                          "Mother's occupation_category", "
a_df_encoded.head()
```

Out[47]:

	Daytime/evening attendance	Previous qualification (grade)	Admission grade	Educational special needs	Debtor	Tuition fees up to date	Scholarship holder	Cur ur
0	1	122.0	127.3	0	0	1	0	0.(
1	1	160.0	142.5	0	0	0	0	14.(
2	1	122.0	124.8	0	0	0	0	0.(
3	1	122.0	119.6	0	0	1	0	13.4
4	0	100.0	141.5	0	0	1	0	12.3

5 rows × 38 columns

Decision Tree Model

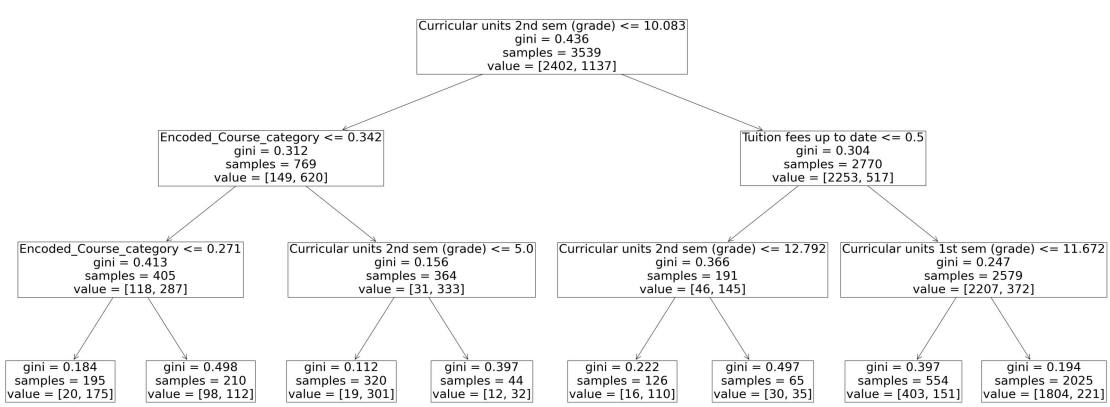
In [48]:
```
# Let's create separate indep. X variables from dep. Y variable
X = a_df_encoded.drop('Target', axis = 1).copy()
y = a_df_encoded['Target'].copy()
```

In [49]:
```
# Checking if the data is imbalanced or not
sum(y)/ len(y)
# 32% of the students have dropped out. We need to make sure that we maint
# this kind of splitting the data maintaining the ratio is called "stratif
```

Out[49]:
```
0.3212025316455696
```

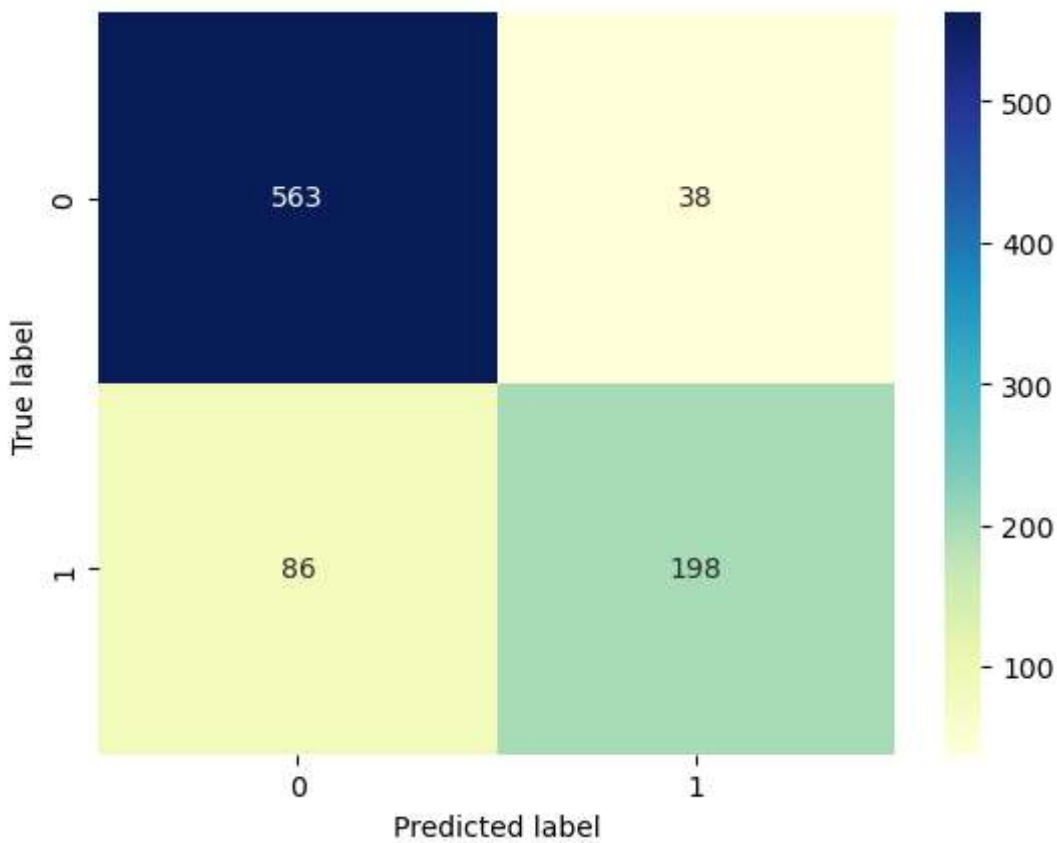
In [50]:
```
# Splitting the data into train and test sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, r
print("train ratio =", sum(y_train)/ len(y_train))
print("test ratio =", sum(y_test)/ len(y_test))

# Creating and fitting the decision tree model
decision_tree = DecisionTreeClassifier(criterion='gini', max_depth=3, rand
decision_tree.fit(X_train, y_train)

# Get the unique target class values
class_values = y.unique()

plt.figure(figsize=(50, 20))
#tree.plot_tree(decision_tree, feature_names=X_train.columns, class_names=
tree.plot_tree(decision_tree, feature_names=X_train.columns, fontsize=30)

# Predicting on the test set
y_pred = decision_tree.predict(X_test)
```

```
train ratio = 0.3212771969482905
test ratio = 0.32090395480225986
```



In [51]:

```
# Generate confusion matrix
cm = confusion_matrix(y_test, y_pred)

# Plot the confusion matrix as a heatmap
sns.heatmap(cm, annot=True, fmt='d', cmap='YlGnBu')
plt.xlabel('Predicted label')
plt.ylabel('True label')
plt.show()
```



In [52]:

```
# Calculating accuracy
accuracy = accuracy_score(y_test, y_pred)
print("\n Accuracy of this Model is : ", accuracy)
```

```
 Accuracy of this Model is :  0.8598870056497175
```

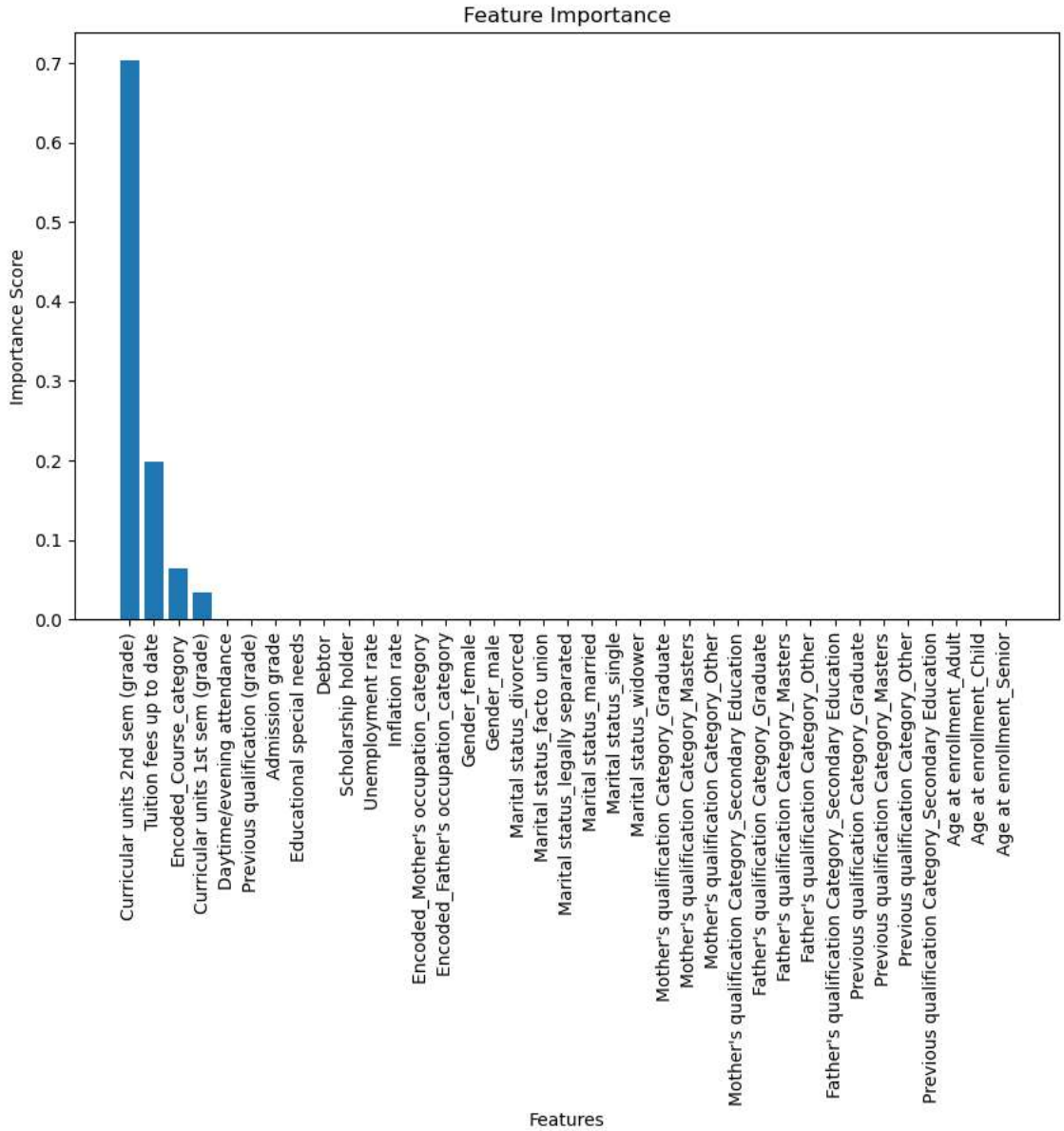
In [53]:

```python
# Generating the classification report
classification_rep = classification_report(y_test, y_pred)
print("Classification Report:")
print(classification_rep)
```

```
Classification Report:
              precision    recall  f1-score   support

           0       0.87      0.94      0.90       601
           1       0.84      0.70      0.76       284

    accuracy                           0.86       885
   macro avg       0.85      0.82      0.83       885
weighted avg       0.86      0.86      0.86       885
```

In [54]:

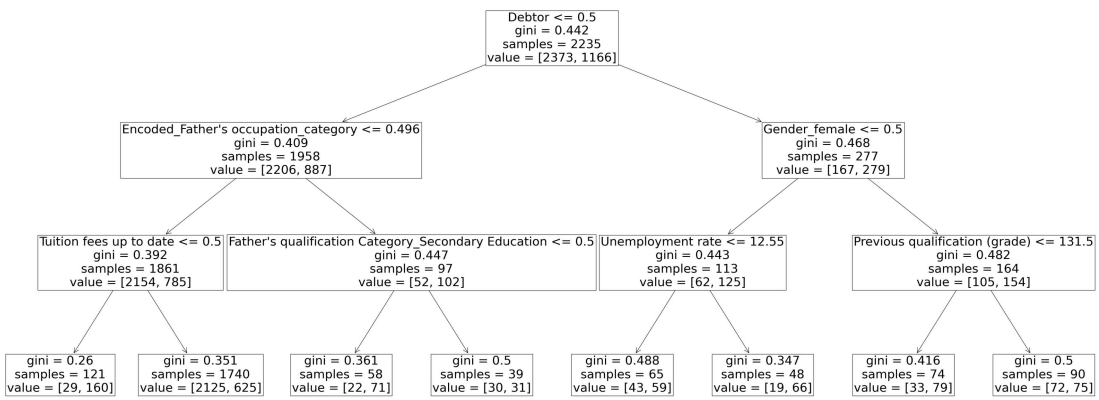
```
importances = decision_tree.feature_importances_
feature_names = X_train.columns

# Create a dictionary to store feature importance scores
feature_importance = dict(zip(feature_names, importances))

# Sort the features by their importance scores in descending order
sorted_features = sorted(feature_importance.items(), key=lambda x: x[1], r

# Extract the feature names and importance scores
features = [feature for feature, _ in sorted_features]
importances = [importance for _, importance in sorted_features]

# Plot the bar graph
plt.figure(figsize=(10, 6))
plt.bar(features, importances)
plt.xticks(rotation=90)
plt.xlabel('Features')
plt.ylabel('Importance Score')
plt.title('Feature Importance')

# Display the plot
plt.show()
```


Feature Importance
Importance Score
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Curricular units 2nd sem (grade)
Tuition fees up to date
Encoded_Course_category
Curricular units 1st sem (grade)
Daytime/evening attendance
Previous qualification (grade)
Admission grade
Educational special needs
Debtor
Scholarship holder
Unemployment rate
Inflation rate
Encoded_Mother's occupation_category
Encoded_Father's occupation_category
Gender_female
Gender_male
Marital status_divorced
Marital status_facto union
Marital status_legally separated
Marital status_married
Marital status_single
Marital status_widower
Mother's qualification Category_Graduate
Mother's qualification Category_Masters
Mother's qualification Category_Other
Mother's qualification Category_Secondary Education
Father's qualification Category_Graduate
Father's qualification Category_Masters
Father's qualification Category_Other
Father's qualification Category_Secondary Education
Previous qualification Category_Graduate
Previous qualification Category_Masters
Previous qualification Category_Other
Previous qualification Category_Secondary Education
Age at enrollment_Adult
Age at enrollment_Child
Age at enrollment_Senior
Features

Random Forest Model

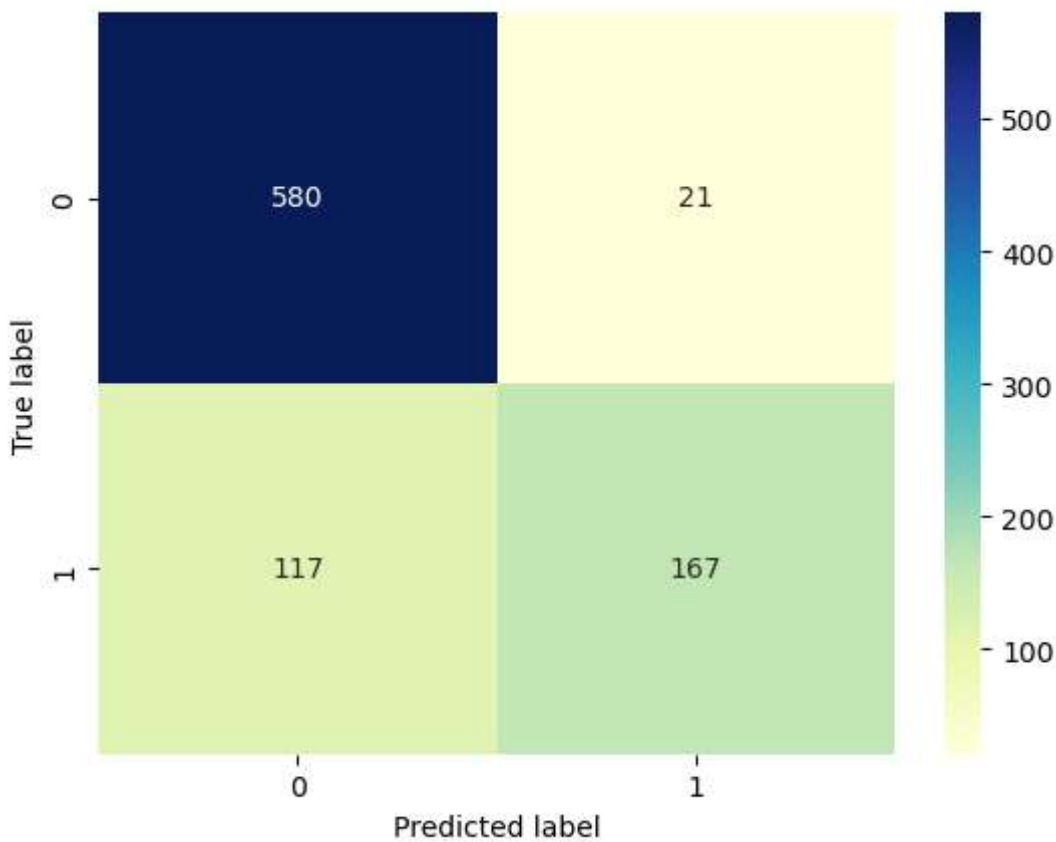
In [55]:

```
# Creating and fitting the Random Forest model
random_forest = RandomForestClassifier(n_estimators=100,criterion='gini',
random_forest.fit(X_train, y_train)

# Choose a tree from the forest to plot (e.g., the first tree)
tree_to_plot = random_forest.estimators_[0]
# Get the unique target class values
class_values = y.unique()

plt.figure(figsize=(50, 20))
#plot_tree(tree_to_plot, feature_names=X_train.columns,class_names=[f'{cla
tree.plot_tree(tree_to_plot, feature_names=X_train.columns, fontsize=30)
plt.show()

# Predicting on the test set
y_pred = random_forest.predict(X_test)
```



In [56]:

```
# Generate confusion matrix
cm = confusion_matrix(y_test, y_pred)

# Plot the confusion matrix as a heatmap
sns.heatmap(cm, annot=True, fmt='d', cmap='YlGnBu')
plt.xlabel('Predicted label')
plt.ylabel('True label')
plt.show()
```



In [57]:

```
# Calculating accuracy
accuracy = accuracy_score(y_test, y_pred)
print("\n Accuracy of this Model is : ", accuracy)
```

```
 Accuracy of this Model is :  0.8440677966101695
```

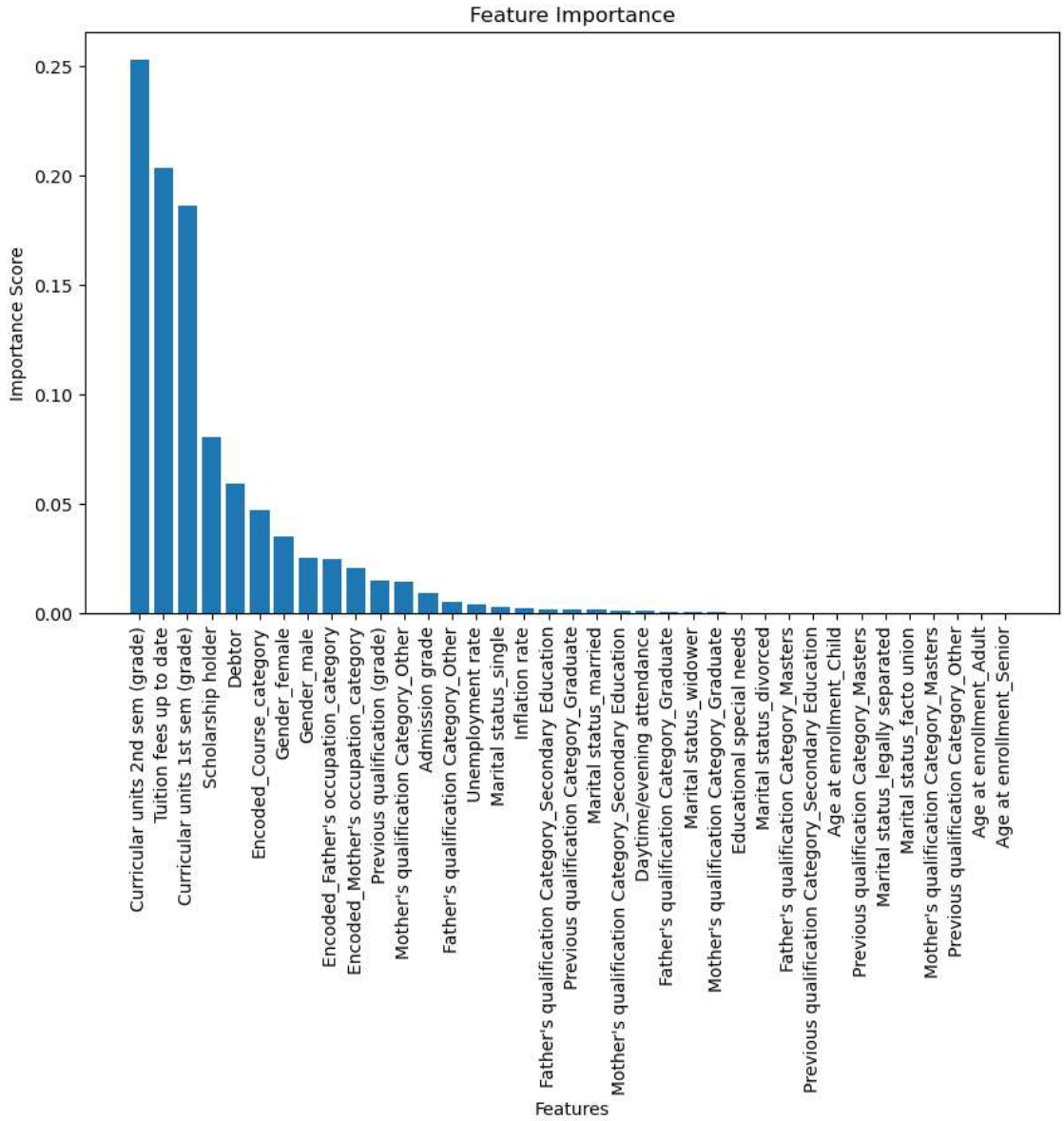
In [58]:

```python
# Generating the classification report
classification_rep = classification_report(y_test, y_pred)
print("Classification Report:")
print(classification_rep)
```

```
Classification Report:
              precision    recall  f1-score   support

           0       0.83      0.97      0.89       601
           1       0.89      0.59      0.71       284

    accuracy                           0.84       885
   macro avg       0.86      0.78      0.80       885
weighted avg       0.85      0.84      0.83       885
```

In [59]:

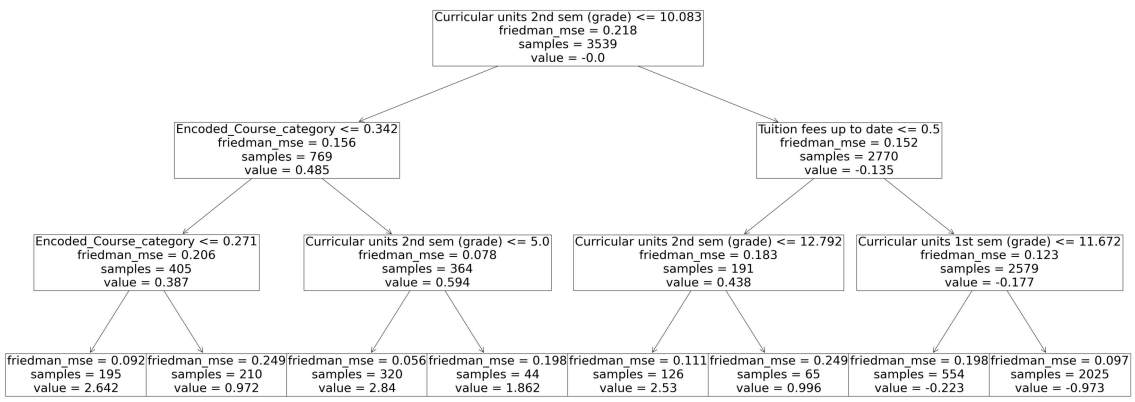
```
importances = random_forest.feature_importances_
feature_names = X_train.columns

# Create a dictionary to store feature importance scores
feature_importance = dict(zip(feature_names, importances))

# Sort the features by their importance scores in descending order
sorted_features = sorted(feature_importance.items(), key=lambda x: x[1], r

# Extract the feature names and importance scores
features = [feature for feature, _ in sorted_features]
importances = [importance for _, importance in sorted_features]

# Plot the bar graph
plt.figure(figsize=(10, 6))
plt.bar(features, importances)
plt.xticks(rotation=90)
plt.xlabel('Features')
plt.ylabel('Importance Score')
plt.title('Feature Importance')

# Display the plot
plt.show()
```


Feature Importance
Importance Score
0.25
0.20
0.15
0.10
0.05
0.00
Curricular units 2nd sem (grade)
Tuition fees up to date
Curricular units 1st sem (grade)
Scholarship holder
Debtor
Encoded_Course_category
Gender_female
Gender_male
Encoded_Father's occupation_category
Encoded_Mother's occupation_category
Previous qualification (grade)
Mother's qualification Category_Other
Admission grade
Father's qualification Category_Other
Unemployment rate
Marital status_single
Inflation rate
Father's qualification Category_Secondary Education
Previous qualification Category_Graduate
Marital status_married
Mother's qualification Category_Secondary Education
Daytime/evening attendance
Father's qualification Category_Graduate
Marital status_widower
Mother's qualification Category_Graduate
Educational special needs
Marital status_divorced
Father's qualification Category_Masters
Previous qualification Category_Secondary Education
Age at enrollment_Child
Previous qualification Category_Masters
Marital status_legally separated
Marital status_facto union
Mother's qualification Category_Masters
Previous qualification Category_Other
Age at enrollment_Adult
Age at enrollment_Senior
Features

Gradient Boost Model

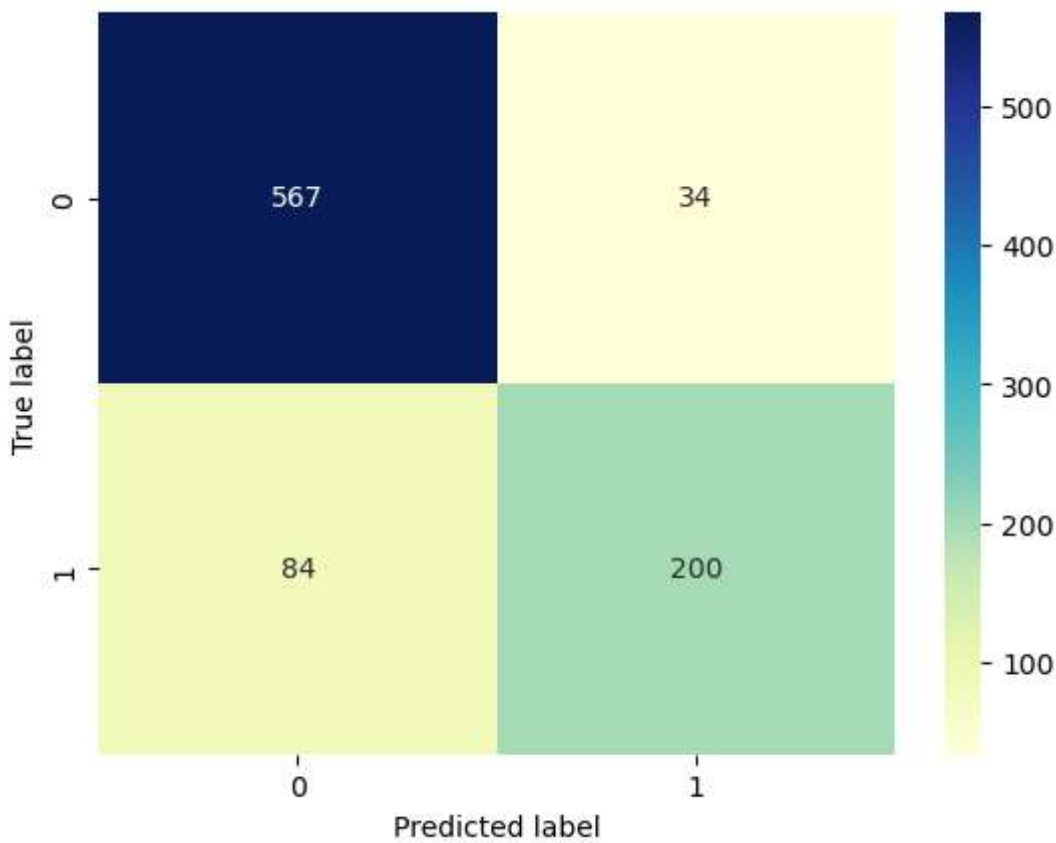
In [60]:

```
# Creating and fitting the Gradient Boosting model
gradient_boost = GradientBoostingClassifier(n_estimators=100, max_depth=3,
gradient_boost.fit(X_train, y_train)

# Choose a tree from the forest to plot (e.g., the first tree)
tree_to_plot = gradient_boost.estimators_[0][0]  # Select the first tree

# Get the unique target class values
class_values = y.unique()

plt.figure(figsize=(50, 20))
plot_tree(tree_to_plot, feature_names=X_train.columns, class_names=[f'{cla
plt.show()

# Predicting on the test set
y_pred = gradient_boost.predict(X_test)
```



In [61]:

```
# Generate confusion matrix
cm = confusion_matrix(y_test, y_pred)

# Plot the confusion matrix as a heatmap
sns.heatmap(cm, annot=True, fmt='d', cmap='YlGnBu')
plt.xlabel('Predicted label')
plt.ylabel('True label')
plt.show()
```



In [62]:

```
# Calculating accuracy
accuracy = accuracy_score(y_test, y_pred)
print("\n Accuracy of this Model is : ", accuracy)
```

```
 Accuracy of this Model is :  0.8666666666666667
```

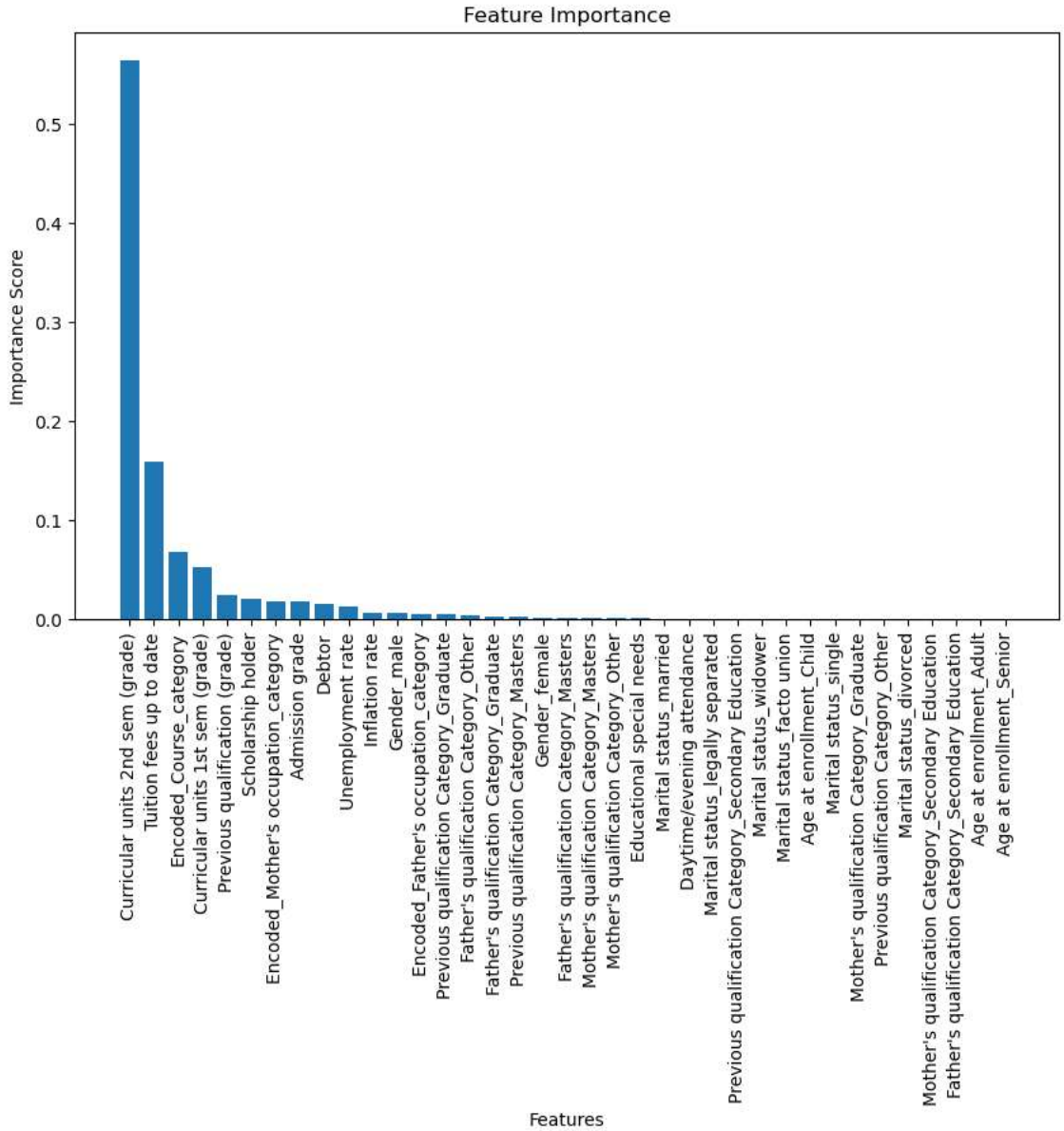
In [63]:

```python
# Generating the classification report
classification_rep = classification_report(y_test, y_pred)
print("Classification Report:")
print(classification_rep)
```

```
Classification Report:
              precision    recall  f1-score   support

           0       0.87      0.94      0.91       601
           1       0.85      0.70      0.77       284

    accuracy                           0.87       885
   macro avg       0.86      0.82      0.84       885
weighted avg       0.87      0.87      0.86       885
```

In [64]:

```
importances = gradient_boost.feature_importances_
feature_names = X_train.columns

# Create a dictionary to store feature importance scores
feature_importance = dict(zip(feature_names, importances))

# Sort the features by their importance scores in descending order
sorted_features = sorted(feature_importance.items(), key=lambda x: x[1], r

# Extract the feature names and importance scores
features = [feature for feature, _ in sorted_features]
importances = [importance for _, importance in sorted_features]

# Plot the bar graph
plt.figure(figsize=(10, 6))
plt.bar(features, importances)
plt.xticks(rotation=90)
plt.xlabel('Features')
plt.ylabel('Importance Score')
plt.title('Feature Importance')

# Display the plot
plt.show()
```


Feature Importance
Importance Score
0.0
0.1
0.2
0.3
0.4
0.5
Curricular units 2nd sem (grade)
Tuition fees up to date
Encoded_Course_category
Curricular units 1st sem (grade)
Previous qualification (grade)
Scholarship holder
Encoded_Mother's occupation_category
Admission grade
Debtor
Unemployment rate
Inflation rate
Gender_male
Encoded_Father's occupation_category
Previous qualification Category_Graduate
Father's qualification Category_Other
Father's qualification Category_Graduate
Previous qualification Category_Masters
Gender_female
Father's qualification Category_Masters
Mother's qualification Category_Masters
Mother's qualification Category_Other
Educational special needs
Marital status_married
Daytime/evening attendance
Marital status_legally separated
Previous qualification Category_Secondary Education
Marital status_widower
Marital status_facto union
Age at enrollment_Child
Marital status_single
Mother's qualification Category_Graduate
Previous qualification Category_Other
Marital status_divorced
Mother's qualification Category_Secondary Education
Father's qualification Category_Secondary Education
Age at enrollment_Adult
Age at enrollment_Senior
Features

Gradient Boosting Machine - XgBoost

In [65]:

```
#pip install graphviz
#pip install python-graphviz

import xgboost as xgb
import matplotlib.pyplot as plt

# Drop rows with missing values from the training set
X_train = X_train.dropna()
y_train = y_train[X_train.index]

# Drop rows with missing values from the test set
X_test = X_test.dropna()
y_test = y_test[X_test.index]

# Creating the XGBClassifier shell
clf_xgb = xgb.XGBClassifier(objective='binary:logistic', seed=42)

# Adding the data and fitting the model with early stopping
clf_xgb.fit(X_train,
            y_train,
            verbose=True,
            early_stopping_rounds=10,
            eval_metric='aucpr',
            eval_set=[(X_test, y_test)])

# Assuming you have already fitted the xgboost_model
y_pred = clf_xgb.predict(X_test)
```

```
[0]	validation_0-aucpr:0.80371
[1]	validation_0-aucpr:0.82043
[2]	validation_0-aucpr:0.81961
[3]	validation_0-aucpr:0.82382
[4]	validation_0-aucpr:0.83064
[5]	validation_0-aucpr:0.83298
[6]	validation_0-aucpr:0.84845
[7]	validation_0-aucpr:0.84566
[8]	validation_0-aucpr:0.84572
[9]	validation_0-aucpr:0.84637
[10]	validation_0-aucpr:0.85012
[11]	validation_0-aucpr:0.84954
[12]	validation_0-aucpr:0.85099
[13]	validation_0-aucpr:0.85349
[14]	validation_0-aucpr:0.85323
[15]	validation_0-aucpr:0.85240
[16]	validation_0-aucpr:0.85084
[17]	validation_0-aucpr:0.85088
[18]	validation_0-aucpr:0.85027
[19]	validation_0-aucpr:0.85014
[20]	validation_0-aucpr:0.84894
[21]	validation_0-aucpr:0.84787
[22]	validation_0-aucpr:0.84905
[23]	validation_0-aucpr:0.84901
```

In [66]:

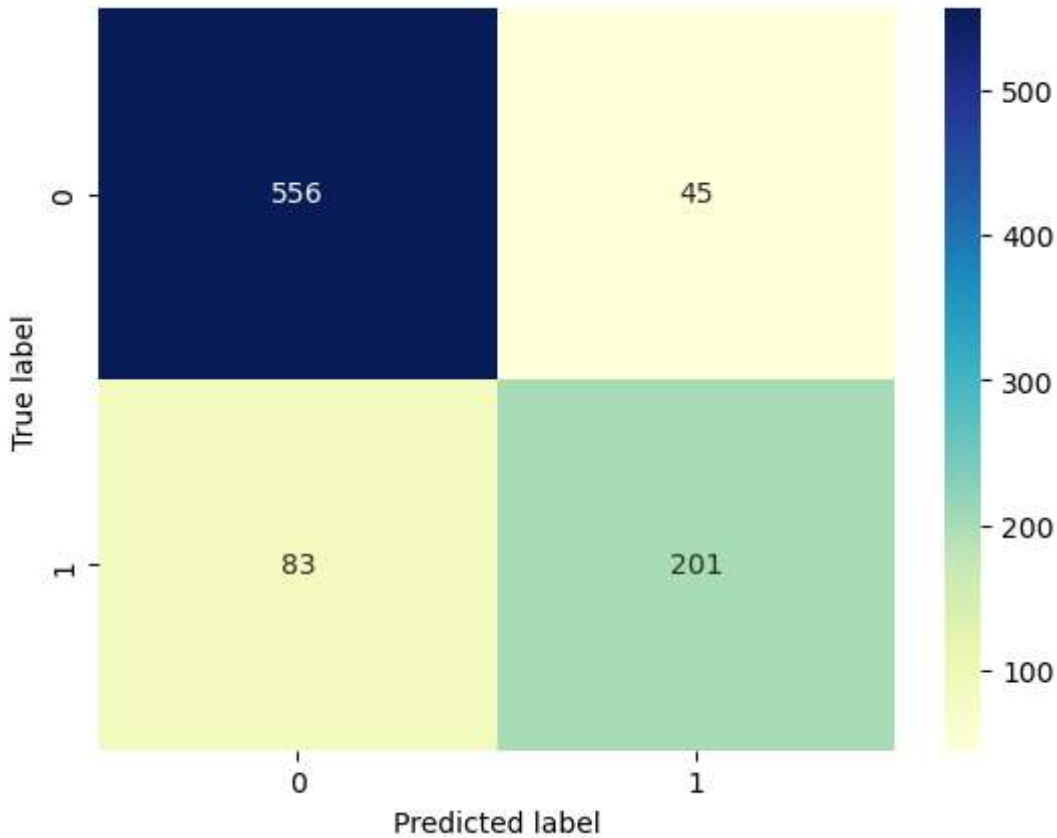
```
xgb.plot_tree(clf_xgb,num_trees = 20)
plt.rcParams['figure.figsize'] = [50, 20]
plt.show()
```

In [67]:

```
clf_xgb.base_score
```

In [68]:

```
plt.rcParams.update(plt.rcParamsDefault)

# Generate confusion matrix
cm = confusion_matrix(y_test, y_pred)

# Plot the confusion matrix as a heatmap
sns.heatmap(cm, annot=True, fmt='d', cmap='YlGnBu')
plt.xlabel('Predicted label')
plt.ylabel('True label')
plt.show()
```



In [69]:

```
# Calculating accuracy
accuracy = accuracy_score(y_test, y_pred)
print("\n Accuracy of this Model is : ", accuracy)
```

```
 Accuracy of this Model is :  0.8553672316384181
```

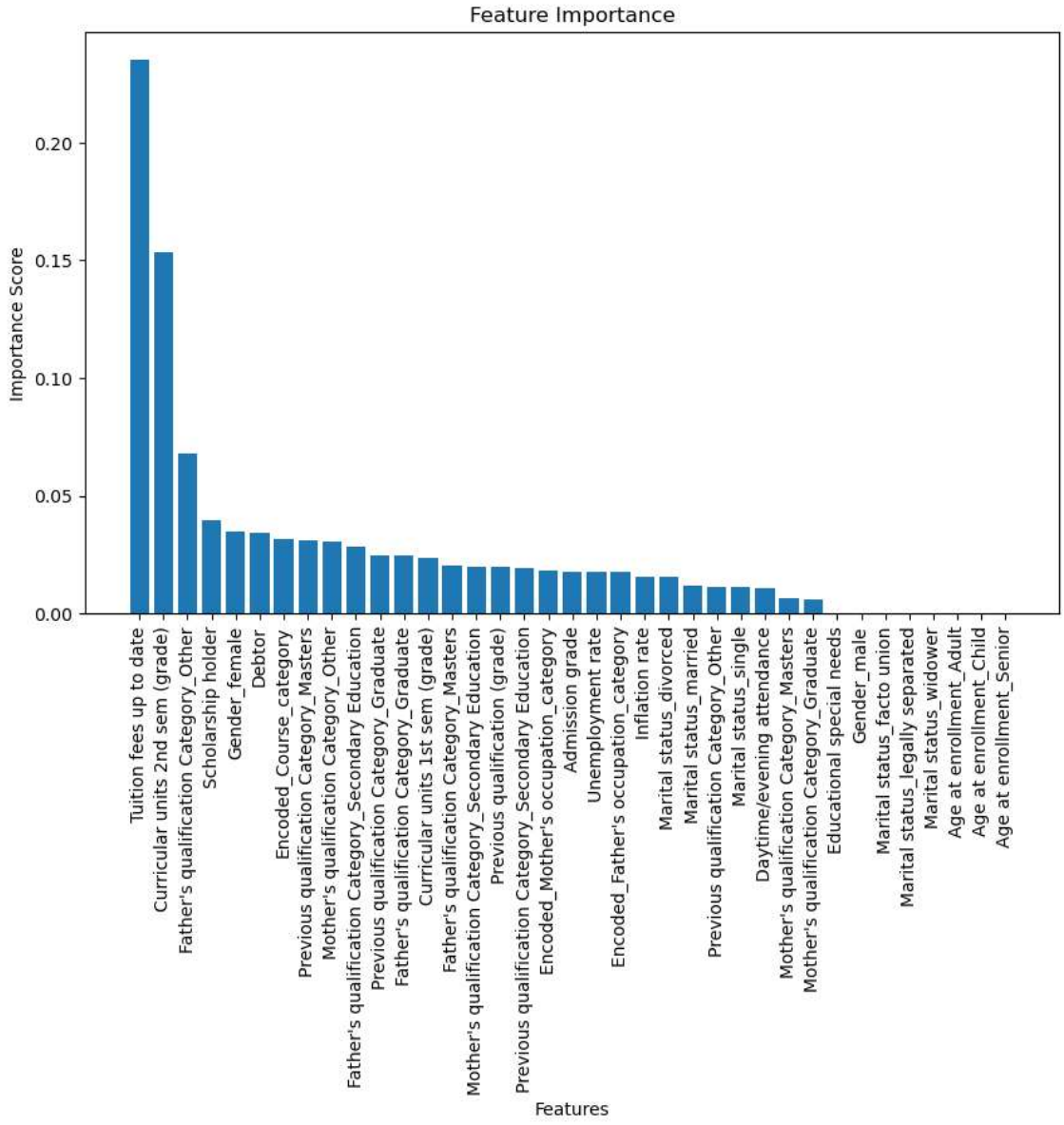
In [70]:

```python
# Generating the classification report
classification_rep = classification_report(y_test, y_pred)
print("Classification Report:")
print(classification_rep)
```

```
Classification Report:
              precision    recall  f1-score   support

           0       0.87      0.93      0.90       601
           1       0.82      0.71      0.76       284

    accuracy                           0.86       885
   macro avg       0.84      0.82      0.83       885
weighted avg       0.85      0.86      0.85       885
```

In [71]:

```
plt.rcParams.update(plt.rcParamsDefault)

importances = clf_xgb.feature_importances_
feature_names = X_train.columns

# Create a dictionary to store feature importance scores
feature_importance = dict(zip(feature_names, importances))

# Sort the features by their importance scores in descending order
sorted_features = sorted(feature_importance.items(), key=lambda x: x[1], r

# Extract the feature names and importance scores
features = [feature for feature, _ in sorted_features]
importances = [importance for _, importance in sorted_features]

# Plot the bar graph
plt.figure(figsize=(10, 6))
plt.bar(features, importances)
plt.xticks(rotation=90)
plt.xlabel('Features')
plt.ylabel('Importance Score')
plt.title('Feature Importance')

# Display the plot
plt.show()
```


Feature Importance
Importance Score
0.00
0.05
0.10
0.15
0.20
Tuition fees up to date
Curricular units 2nd sem (grade)
Father's qualification Category_Other
Scholarship holder
Gender_female
Debtor
Encoded_Course_category
Previous qualification Category_Masters
Mother's qualification Category_Other
Father's qualification Category_Secondary Education
Previous qualification Category_Graduate
Father's qualification Category_Graduate
Curricular units 1st sem (grade)
Father's qualification Category_Masters
Mother's qualification Category_Secondary Education
Previous qualification (grade)
Previous qualification Category_Secondary Education
Encoded_Mother's occupation_category
Admission grade
Unemployment rate
Encoded_Father's occupation_category
Inflation rate
Marital status_divorced
Marital status_married
Previous qualification Category_Other
Marital status_single
Daytime/evening attendance
Mother's qualification Category_Masters
Mother's qualification Category_Graduate
Educational special needs
Gender_male
Marital status_facto union
Marital status_legally separated
Marital status_widower
Age at enrollment_Adult
Age at enrollment_Child
Age at enrollment_Senior
Features

Model Optimization

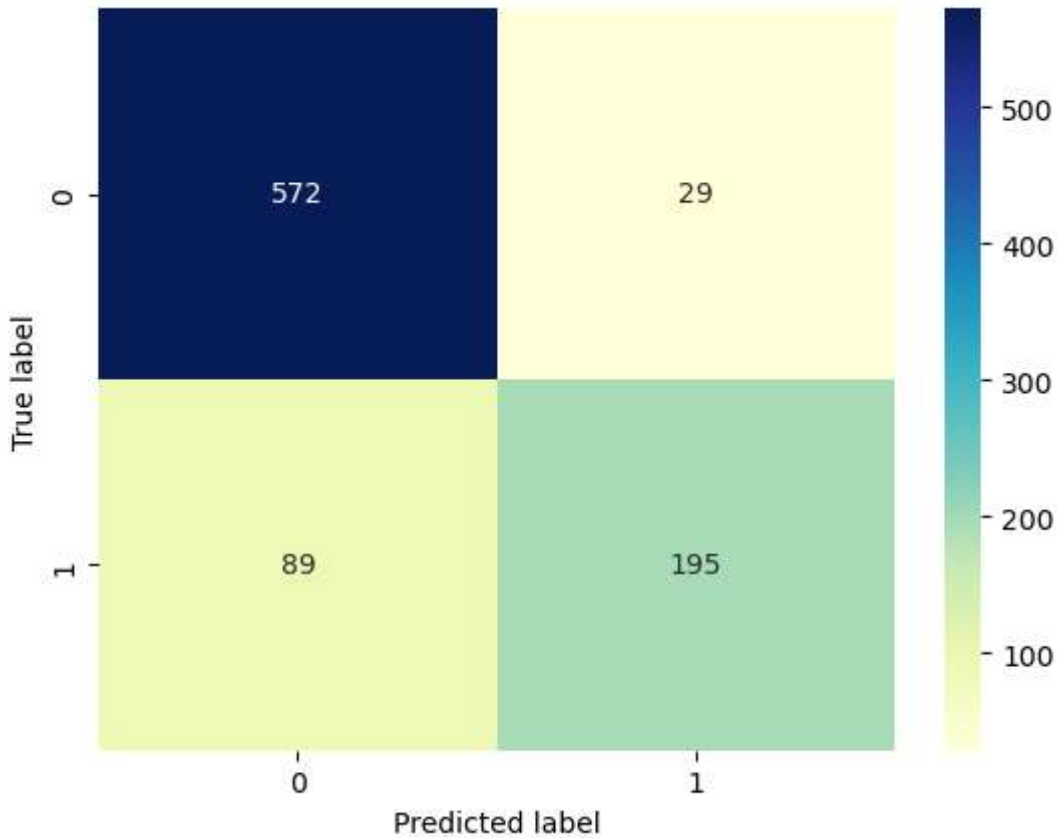
In [72]:

```
import xgboost as xgb
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV

# Drop rows with missing values from the training set
X_train = X_train.dropna()
y_train = y_train[X_train.index]

# Drop rows with missing values from the test set
X_test = X_test.dropna()
y_test = y_test[X_test.index]

# Creating the XGBClassifier shell
clf_xgb = xgb.XGBClassifier(objective='binary:logistic', seed=42)

# Defining the hyperparameters to tune and their possible values
param_grid = {
    'max_depth': [3, 5, 7],                # Maximum depth of a tree
    'learning_rate': [0.1, 0.01, 0.001],  # Step size shrinkage used to pr
    'n_estimators': [100, 200, 300]        # Number of boosting rounds
}

# Creating the grid search object with the XGBoost classifier and hyperpar
grid_search = GridSearchCV(estimator=clf_xgb, param_grid=param_grid, scori

# Fitting the grid search object to the data
grid_search.fit(X_train, y_train)

# Getting the best hyperparameters from the grid search
best_params = grid_search.best_params_
print("Best Hyperparameters:", best_params)

# Fitting the model with the best hyperparameters
clf_xgb_best = xgb.XGBClassifier(objective='binary:logistic', seed=42, **b
clf_xgb_best.fit(X_train, y_train, verbose=True, early_stopping_rounds=10,
```

```
[44]	validation_0-aucpr:0.86461
[45]	validation_0-aucpr:0.86503
[46]	validation_0-aucpr:0.86486
[47]	validation_0-aucpr:0.86521
[48]	validation_0-aucpr:0.86547
[49]	validation_0-aucpr:0.86539
[50]	validation_0-aucpr:0.86590
[51]	validation_0-aucpr:0.86595
[52]	validation_0-aucpr:0.86610
[53]	validation_0-aucpr:0.86660
[54]	validation_0-aucpr:0.86662
[55]	validation_0-aucpr:0.86679
[56]	validation_0-aucpr:0.86733
[57]	validation_0-aucpr:0.86720
[58]	validation_0-aucpr:0.86796
[59]	validation_0-aucpr:0.86804
[60]	validation_0-aucpr:0.86842
[61]	validation_0-aucpr:0.86808
[62]	validation_0-aucpr:0.86828
[63]	validation_0-aucpr:0.86825
```

In [73]:

```
# Assuming you have already fitted the xgboost_model
y_pred = clf_xgb_best.predict(X_test)

# Compute confusion matrix and plot it
cm = confusion_matrix(y_test, y_pred)

sns.heatmap(cm, annot=True, fmt='d', cmap='YlGnBu')
plt.xlabel('Predicted label')
plt.ylabel('True label')
plt.show()
```



In [74]:

```
# Calculating accuracy
accuracy = accuracy_score(y_test, y_pred)
print("\n Accuracy of this Model is : ", accuracy)
```

```
 Accuracy of this Model is :  0.8666666666666667
```

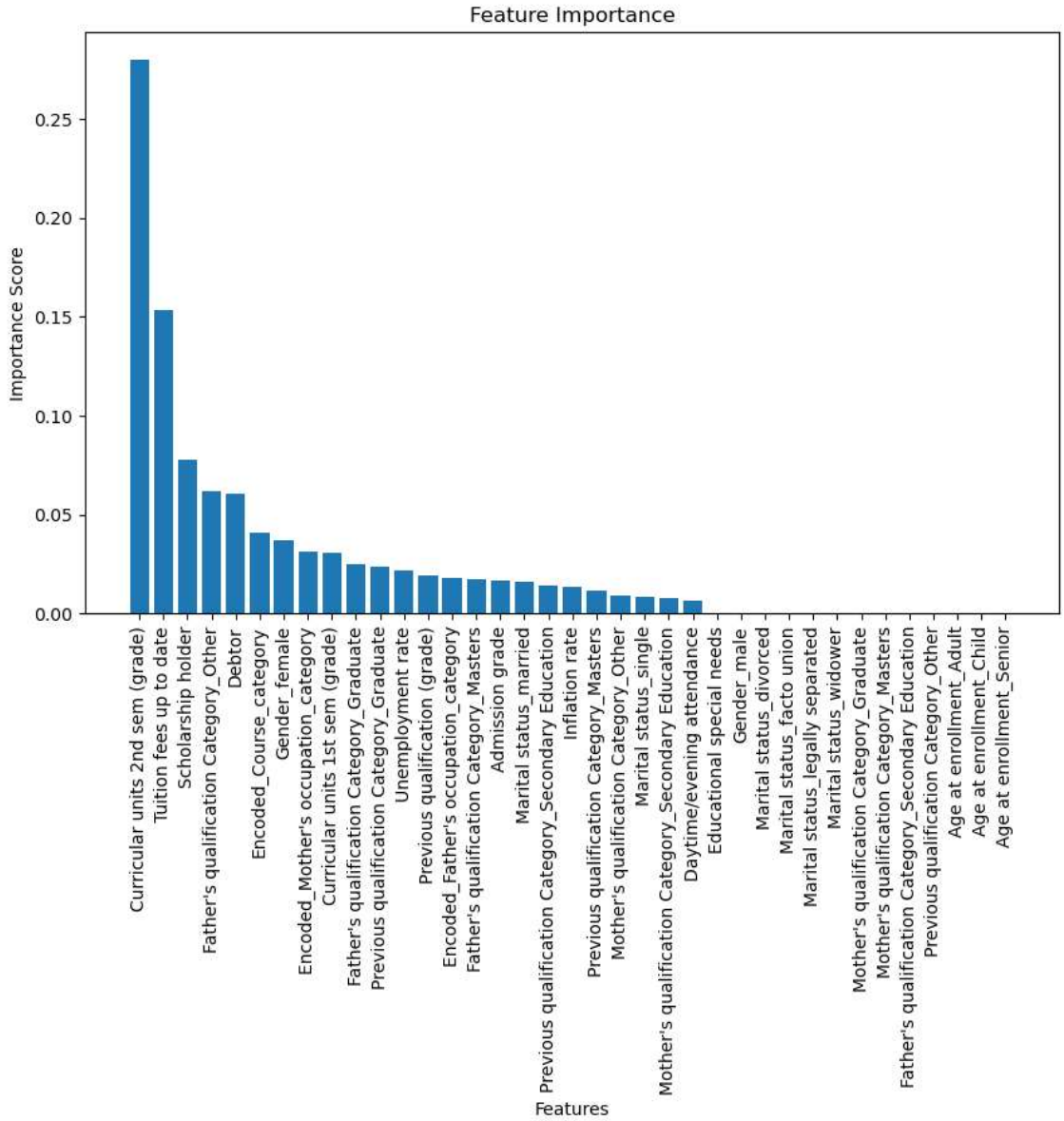
In [75]:

```python
# Generating the classification report
classification_rep = classification_report(y_test, y_pred)
print("Classification Report:")
print(classification_rep)
```

```
Classification Report:
              precision    recall  f1-score   support

           0       0.87      0.95      0.91       601
           1       0.87      0.69      0.77       284

    accuracy                           0.87       885
   macro avg       0.87      0.82      0.84       885
weighted avg       0.87      0.87      0.86       885
```

In [76]:

```
plt.rcParams.update(plt.rcParamsDefault)

importances = clf_xgb_best.feature_importances_
feature_names = X_train.columns

# Create a dictionary to store feature importance scores
feature_importance = dict(zip(feature_names, importances))

# Sort the features by their importance scores in descending order
sorted_features = sorted(feature_importance.items(), key=lambda x: x[1], r

# Extract the feature names and importance scores
features = [feature for feature, _ in sorted_features]
importances = [importance for _, importance in sorted_features]

# Plot the bar graph
plt.figure(figsize=(10, 6))
plt.bar(features, importances)
plt.xticks(rotation=90)
plt.xlabel('Features')
plt.ylabel('Importance Score')
plt.title('Feature Importance')

# Display the plot
plt.show()
```


Feature Importance
Importance Score
0.00
0.05
0.10
0.15
0.20
0.25
Curricular units 2nd sem (grade)
Tuition fees up to date
Scholarship holder
Father's qualification Category_Other
Debtor
Encoded_Course_category
Gender_female
Encoded_Mother's occupation_category
Curricular units 1st sem (grade)
Father's qualification Category_Graduate
Previous qualification Category_Graduate
Unemployment rate
Previous qualification (grade)
Encoded_Father's occupation_category
Father's qualification Category_Masters
Admission grade
Marital status_married
Previous qualification Category_Secondary Education
Inflation rate
Previous qualification Category_Masters
Mother's qualification Category_Other
Marital status_single
Mother's qualification Category_Secondary Education
Daytime/evening attendance
Educational special needs
Gender_male
Marital status_divorced
Marital status_facto union
Marital status_legally separated
Marital status_widower
Mother's qualification Category_Graduate
Mother's qualification Category_Masters
Father's qualification Category_Secondary Education
Previous qualification Category_Other
Age at enrollment_Adult
Age at enrollment_Child
Age at enrollment_Senior
Features

Logistic Regression

In [77]:

```
# Create a logistic regression model
model = LogisticRegression()

# Use RFE to select the top 10 features
num_features_to_select = 10
rfe = RFE(model, n_features_to_select=num_features_to_select)
rfe.fit(X, y)

# Get the selected feature names
selected_feature_names = X.columns[rfe.support_]

# Print the selected feature names
print("Selected Features:")
print(selected_feature_names)
```

```
Selected Features:
Index(['Tuition fees up to date', 'Scholarship holder',
       'Encoded_Course_category', 'Encoded_Mother's occupation_category',
       'Encoded_Father's occupation_category', 'Gender_male',
       'Marital status_legally separated',
       'Mother's qualification Category_Other',
       'Previous qualification Category_Graduate', 'Age at enrollment_Chi
ld'],
      dtype='object')
```

In [78]:

```
# Update the X with the new selected features
X= X[selected_feature_names]
```

In [79]:

```
# Checking if the data is imbalanced or not
sum(y)/ len(y)
# 32% of the students have dropped out. We need to make sure that we maint
# this kind of splitting the data maintaining the ratio is called "stratif
```

Out[79]:

```
0.3212025316455696
```

In [80]:

```
# Splitting the data into train and test sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, r
print("train ratio =", sum(y_train)/ len(y_train))
print("test ratio =", sum(y_test)/ len(y_test))
```

```
train ratio = 0.3212771969482905
test ratio = 0.32090395480225986
```

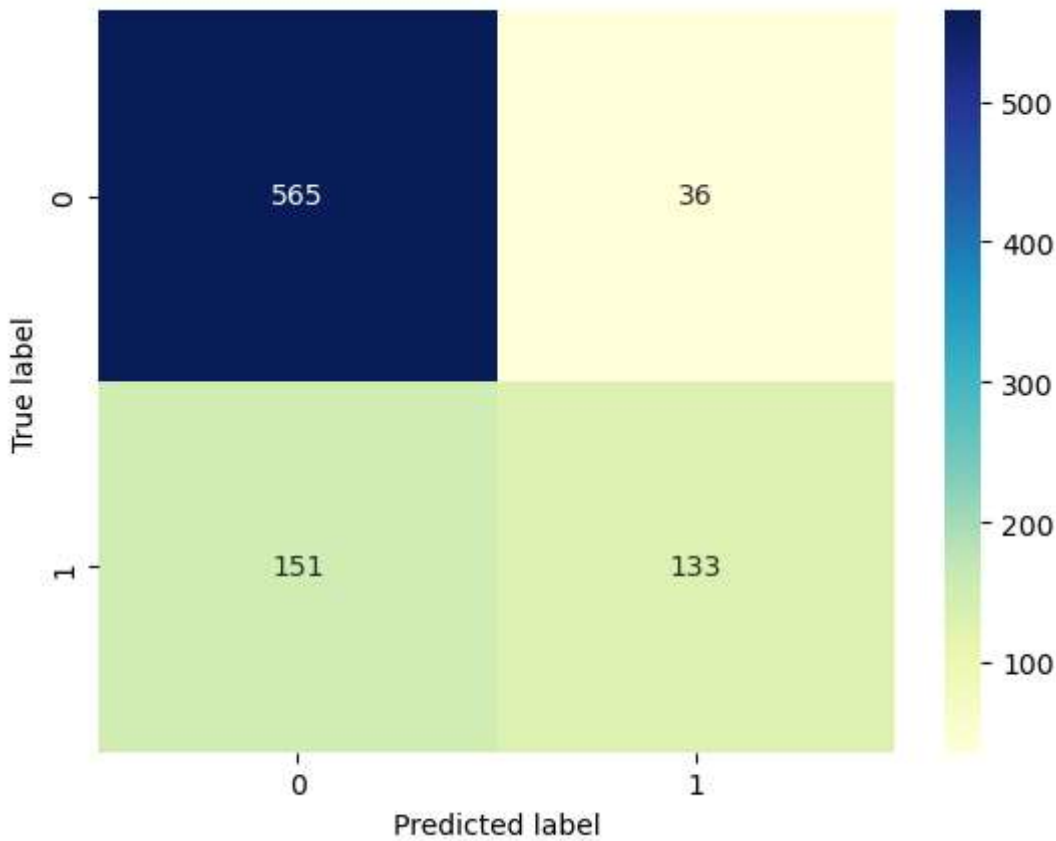
In [81]:

```
# Standardize the feature matrix to avoid scaling issues with regularizati
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)

# Store the feature names in a separate list or array.
feature_names = list(X.columns)

# Creating and fitting the logistic regression model with L1 regularizatio
log_reg = LogisticRegression(penalty='l1', solver='liblinear', random_stat
log_reg.fit(X_train_scaled, y_train)

# Extract coefficients and Exponential Coefficient
coefficients = log_reg.coef_[0]
exp_coefficients = np.exp(coefficients)

# Create a DataFrame to store the results
result_df = pd.DataFrame({'Feature': feature_names, 'Coefficient': coeffic

# Print the result
print(result_df)

# Predicting on the test set
y_pred = log_reg.predict(X_test_scaled)
```

```
                                   Feature  Coefficient  \
0                   Tuition fees up to date    -0.907047
1                        Scholarship holder    -0.457809
2                   Encoded_Course_category     0.334468
3      Encoded_Mother's occupation_category     0.282417
4      Encoded_Father's occupation_category     0.063203
5                               Gender_male     0.251678
6          Marital status_legally separated     0.082618
7     Mother's qualification Category_Other     0.092034
8  Previous qualification Category_Graduate     0.146597
9                   Age at enrollment_Child    -0.127987

   Exponential_Coefficient
0                 0.403715
1                 0.632668
2                 1.397196
3                 1.326331
4                 1.065243
5                 1.286182
6                 1.086127
7                 1.096402
8                 1.157887
9                 0.879865
```

In [82]:

```
plt.rcParams.update(plt.rcParamsDefault)

# Generate confusion matrix
cm = confusion_matrix(y_test, y_pred)

# Plot the confusion matrix as a heatmap
sns.heatmap(cm, annot=True, fmt='d', cmap='YlGnBu')
plt.xlabel('Predicted label')
plt.ylabel('True label')
plt.show()
```



In [83]:

```
# Calculating accuracy
accuracy = accuracy_score(y_test, y_pred)
print("\n Accuracy of this Model is : ", accuracy)
```

```
 Accuracy of this Model is :  0.7887005649717514
```

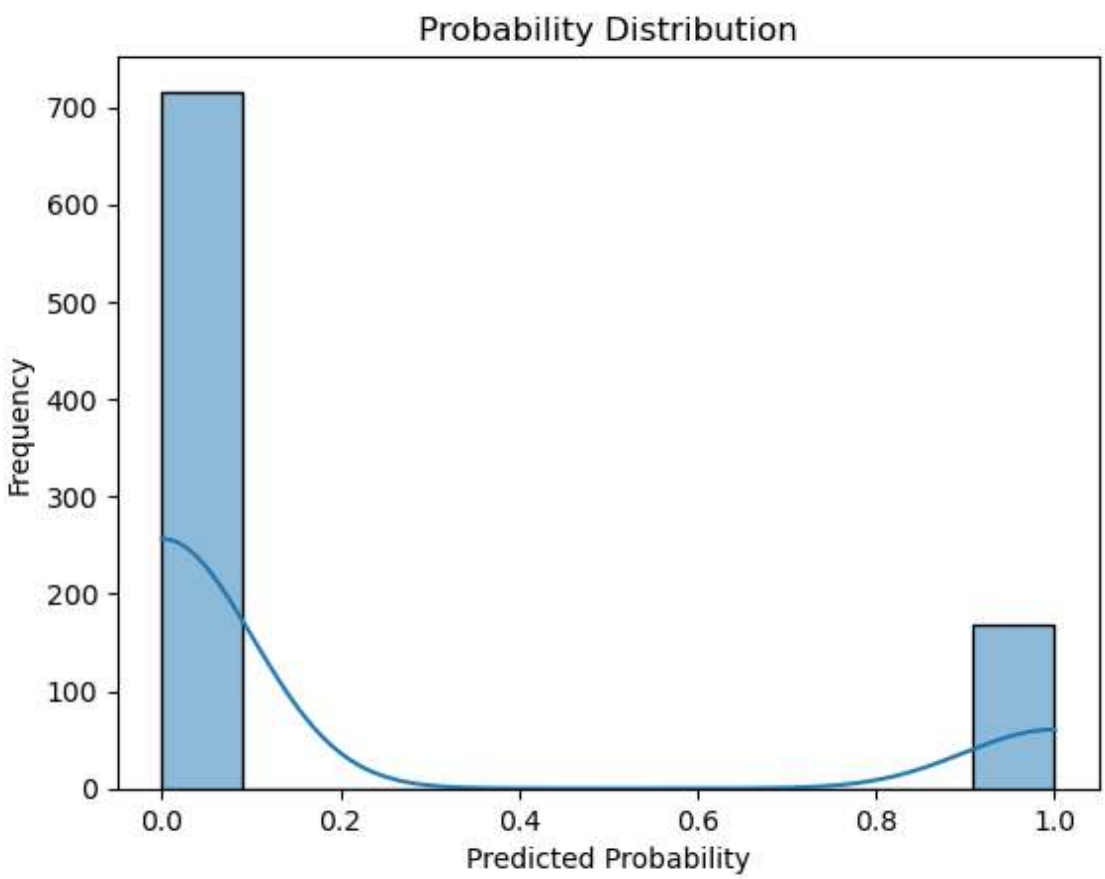
In [84]:

```
# Generating the classification report
classification_rep = classification_report(y_test, y_pred)
print("Classification Report:")
print(classification_rep)
```

```
Classification Report:
              precision    recall  f1-score   support

           0       0.79      0.94      0.86       601
           1       0.79      0.47      0.59       284

    accuracy                           0.79       885
   macro avg       0.79      0.70      0.72       885
weighted avg       0.79      0.79      0.77       885
```

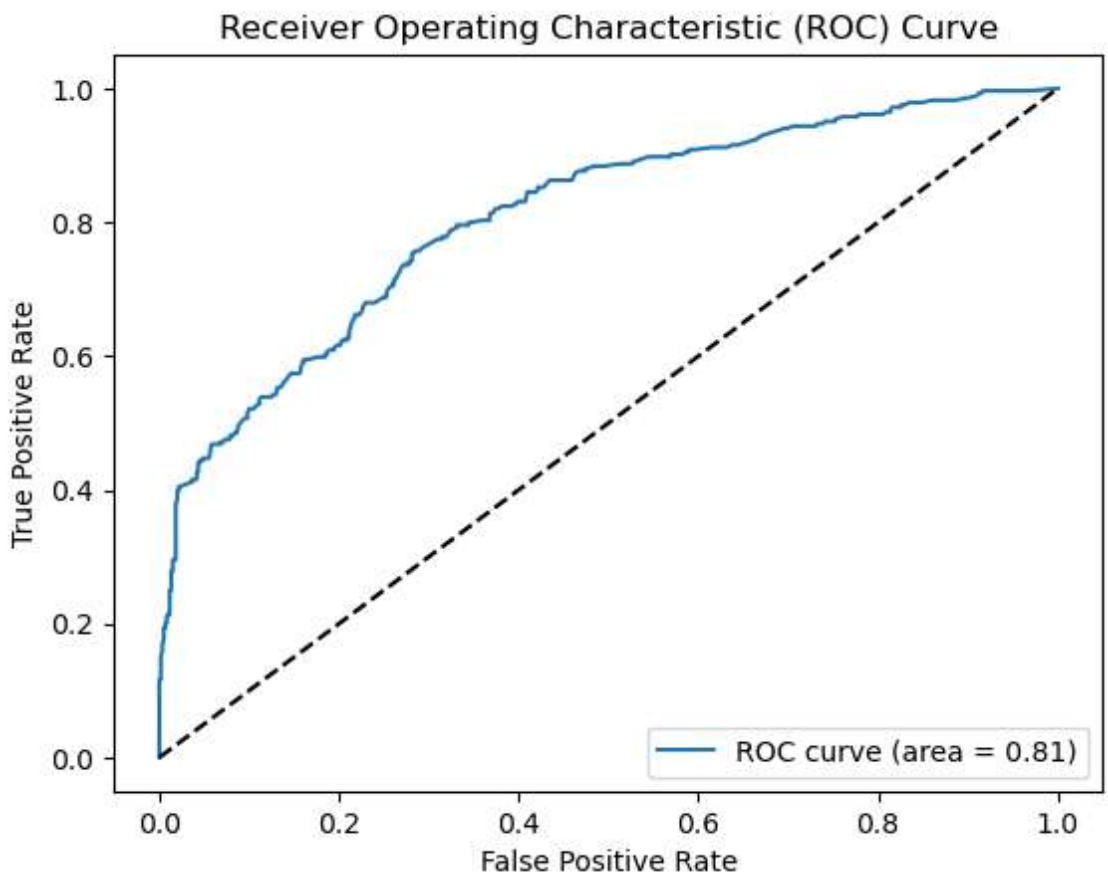
In [85]:

```
plt.rcParams.update(plt.rcParamsDefault)

# Plot the probability distribution of predicted probabilities
sns.histplot(y_pred, kde=True)
plt.xlabel('Predicted Probability')
plt.ylabel('Frequency')
plt.title('Probability Distribution')
plt.show()
```



In [86]:

```
plt.rcParams.update(plt.rcParamsDefault)

y_pred_proba = log_reg.predict_proba(X_test_scaled)[::,1]

# Calculate the false positive rate, true positive rate, and thresholds
fpr, tpr, thresholds = roc_curve(y_test, y_pred_proba)

# Calculate the area under the ROC curve (AUC)
auc = roc_auc_score(y_test, y_pred_proba)

# Plot ROC curve
plt.plot(fpr, tpr, label='ROC curve (area = %0.2f)' % auc)
plt.plot([0, 1], [0, 1], 'k--')  # Plot the diagonal line
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.legend(loc='lower right')
plt.show()
```

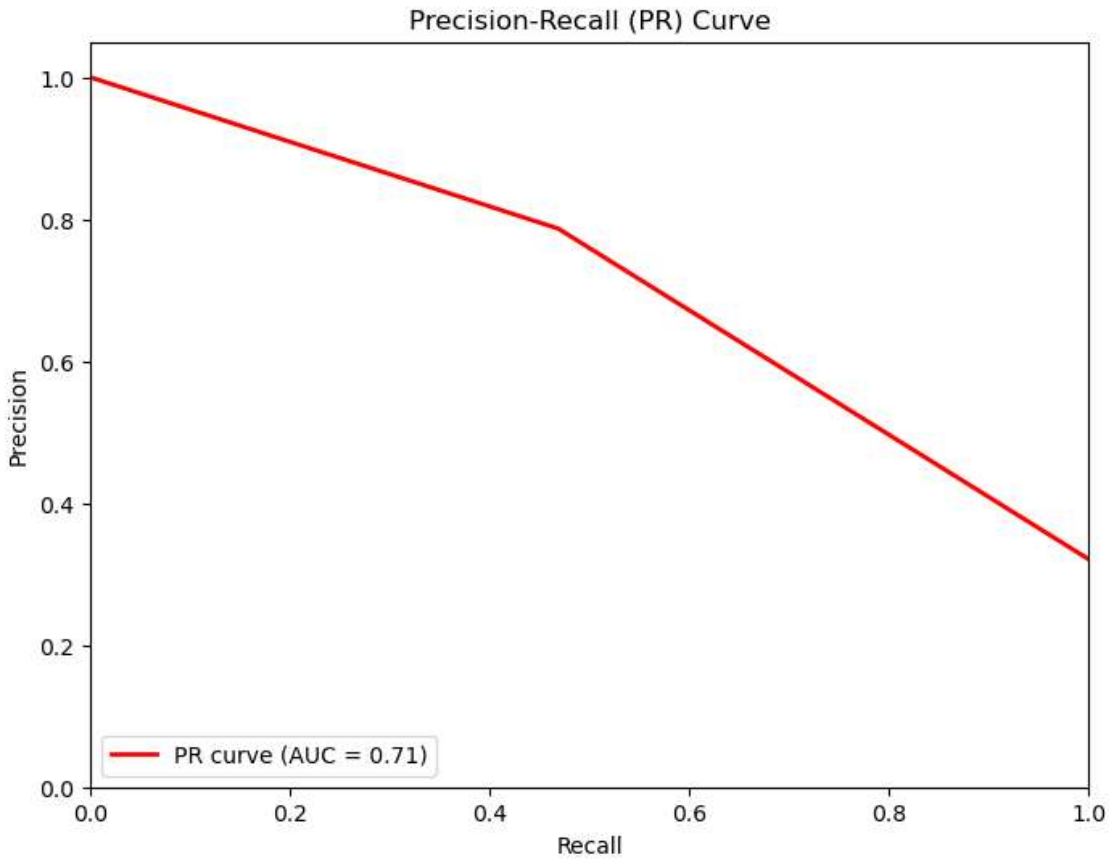


In [87]:

```
import matplotlib.pyplot as plt
from sklearn.metrics import roc_curve, roc_auc_score, precision_recall_cur
import numpy as np
plt.rcParams.update(plt.rcParamsDefault)

# Assuming you have already trained your logistic regression model and obt

# Calculate ROC curve and AUC
fpr, tpr, _ = roc_curve(y_test, y_pred)
roc_auc = auc(fpr, tpr)

# Calculate Precision-Recall curve and AUC
precision, recall, _ = precision_recall_curve(y_test, y_pred)
pr_auc = auc(recall, precision)

# Calculate Gini coefficient (Lorentz curve)
lorentz_curve = np.cumsum(np.sort(y_test)[::-1]) / np.sum(y_test)
gini_coefficient = 2 * auc(np.linspace(0, 1, len(lorentz_curve)), lorentz_
```

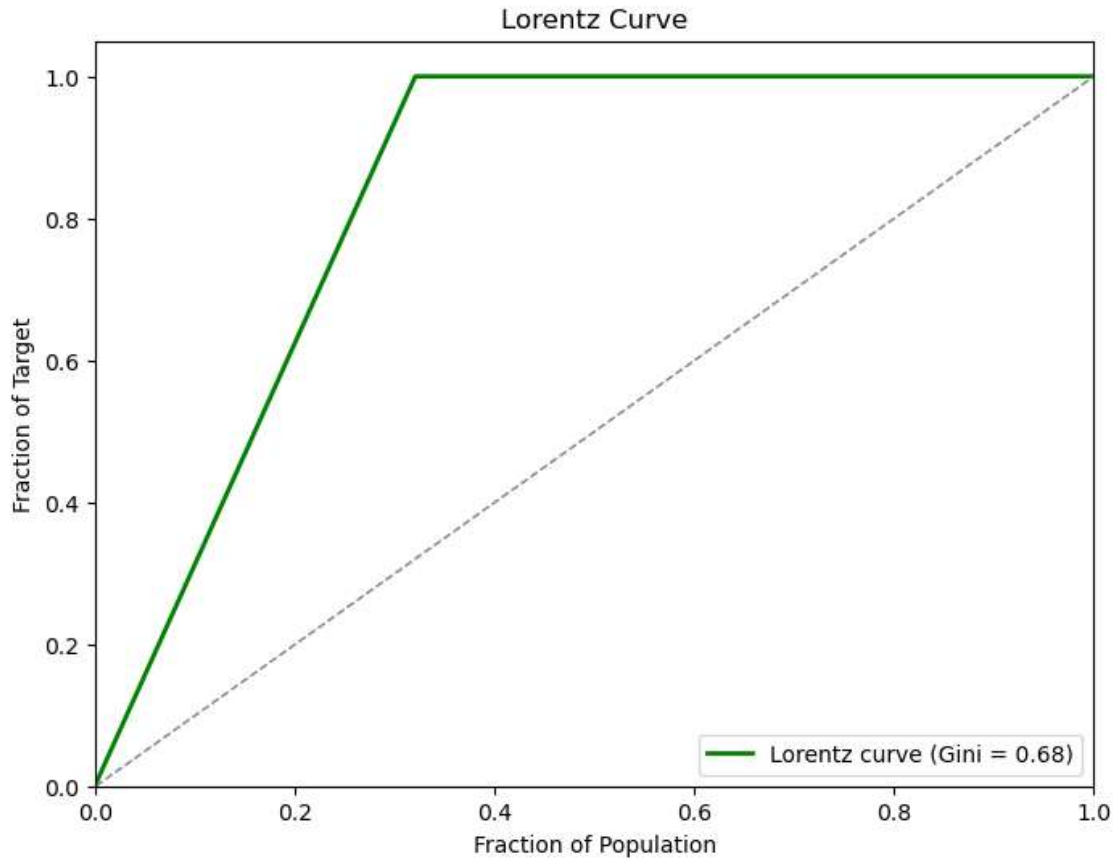
In [88]:

```
# Plot PR curve
plt.figure(figsize=(8, 6))
plt.plot(recall, precision, color='red', lw=2, label='PR curve (AUC = %0.2
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('Recall')
plt.ylabel('Precision')
plt.title('Precision-Recall (PR) Curve')
plt.legend(loc='lower left')
plt.show()
```



In [89]:

```
# Plot Lorentz curve
plt.figure(figsize=(8, 6))
plt.plot(np.linspace(0, 1, len(lorentz_curve)), lorentz_curve, color='gree
plt.plot([0, 1], [0, 1], color='gray', lw=1, linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('Fraction of Population')
plt.ylabel('Fraction of Target')
plt.title('Lorentz Curve')
plt.legend(loc='lower right')
plt.show()
```



Ridge Regularization

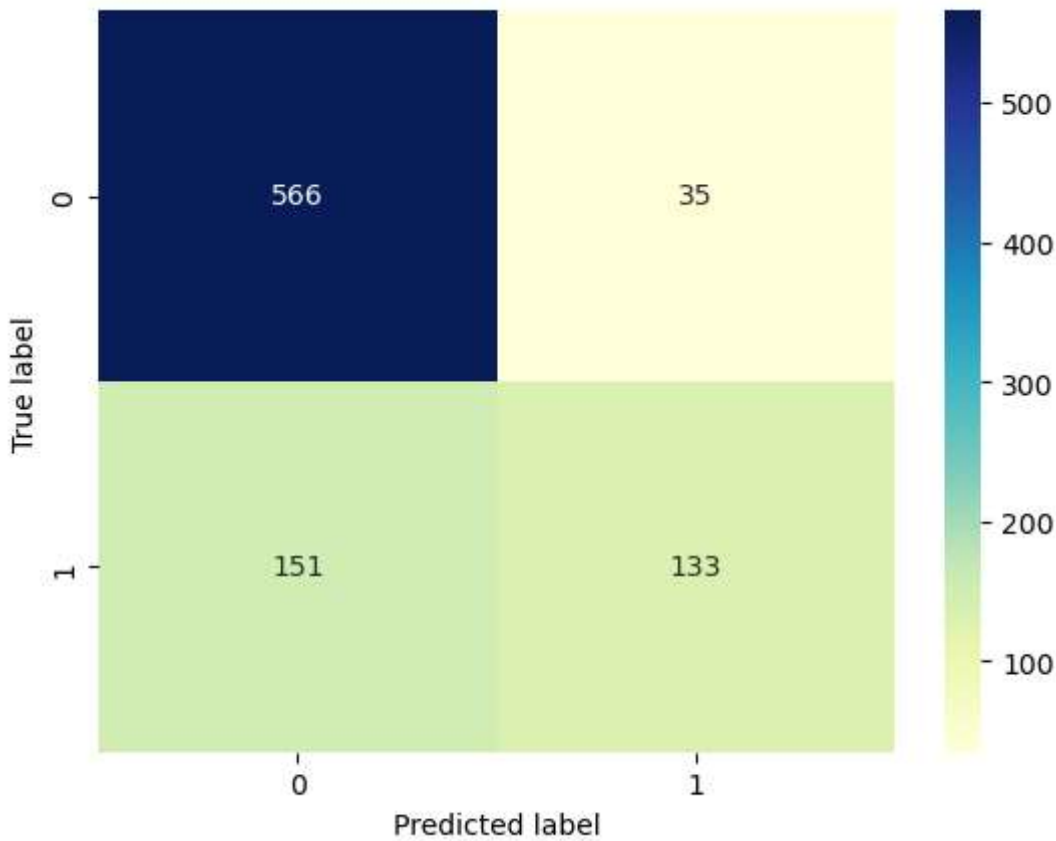
In [90]:

```
# Standardize the feature matrix to avoid scaling issues with regularizati
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)

# Store the feature names in a separate list or array.
feature_names = list(X.columns)

# Creating and fitting the logistic regression model with L1 regularizatio
log_reg = LogisticRegression(penalty='l2', solver='liblinear', random_stat
log_reg.fit(X_train_scaled, y_train)

# Extract coefficients and Exponential Coefficient
coefficients = log_reg.coef_[0]
exp_coefficients = np.exp(coefficients)

# Create a DataFrame to store the results
result_df = pd.DataFrame({'Feature': feature_names, 'Coefficient': coeffic

# Print the result
print(result_df)

# Predicting on the test set
y_pred = log_reg.predict(X_test_scaled)
```

```
                                   Feature  Coefficient  \
0                   Tuition fees up to date    -0.907407
1                        Scholarship holder    -0.458880
2                   Encoded_Course_category     0.335447
3      Encoded_Mother's occupation_category     0.282437
4      Encoded_Father's occupation_category     0.064201
5                               Gender_male     0.252865
6          Marital status_legally separated     0.084375
7     Mother's qualification Category_Other     0.093163
8  Previous qualification Category_Graduate     0.147886
9                   Age at enrollment_Child    -0.186060

   Exponential_Coefficient
0                 0.403569
1                 0.631991
2                 1.398565
3                 1.326358
4                 1.066307
5                 1.287710
6                 1.088036
7                 1.097641
8                 1.159381
9                 0.830224
```

In [91]:

```
plt.rcParams.update(plt.rcParamsDefault)

# Generate confusion matrix
cm = confusion_matrix(y_test, y_pred)

# Plot the confusion matrix as a heatmap
sns.heatmap(cm, annot=True, fmt='d', cmap='YlGnBu')
plt.xlabel('Predicted label')
plt.ylabel('True label')
plt.show()
```



In [92]:

```
# Calculating accuracy
accuracy = accuracy_score(y_test, y_pred)
print("\n Accuracy of this Model is : ", accuracy)
```

```
 Accuracy of this Model is :  0.7898305084745763
```

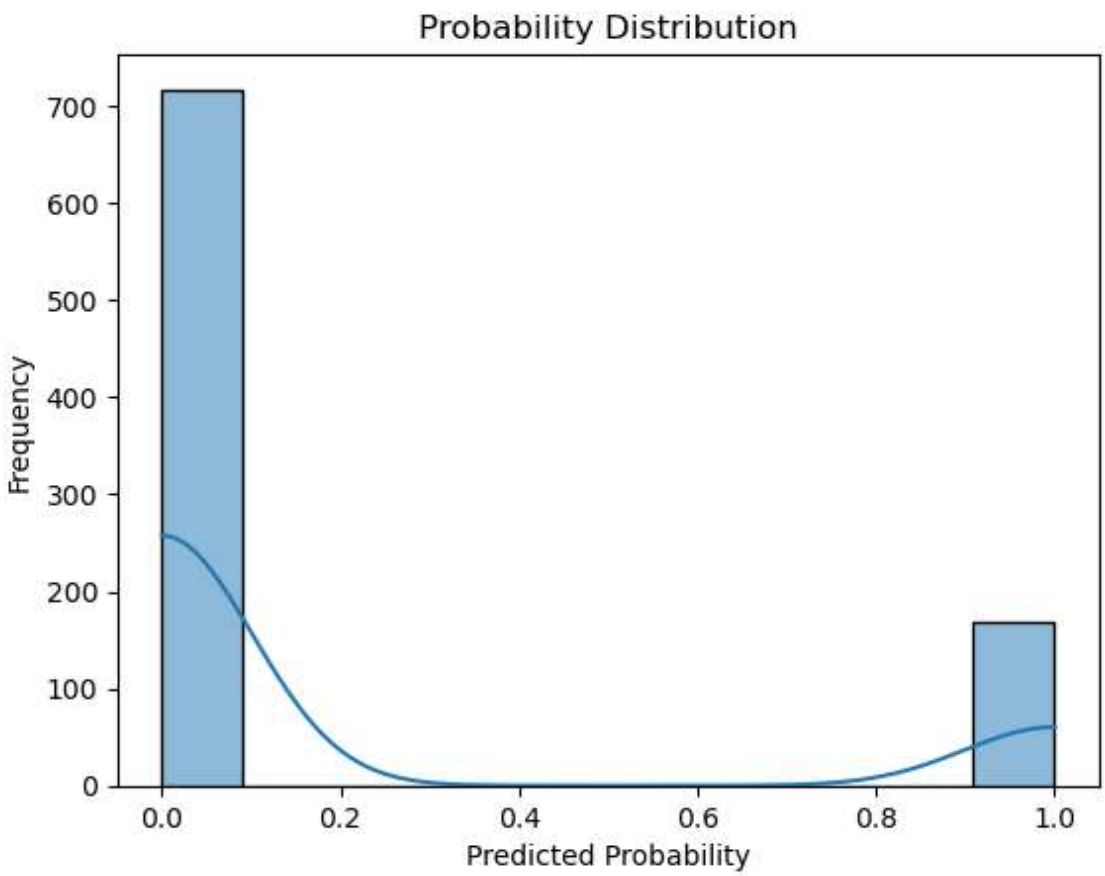
In [93]:

```
# Generating the classification report
classification_rep = classification_report(y_test, y_pred)
print("Classification Report:")
print(classification_rep)
```

```
Classification Report:
              precision    recall  f1-score   support

           0       0.79      0.94      0.86       601
           1       0.79      0.47      0.59       284

    accuracy                           0.79       885
   macro avg       0.79      0.71      0.72       885
weighted avg       0.79      0.79      0.77       885
```

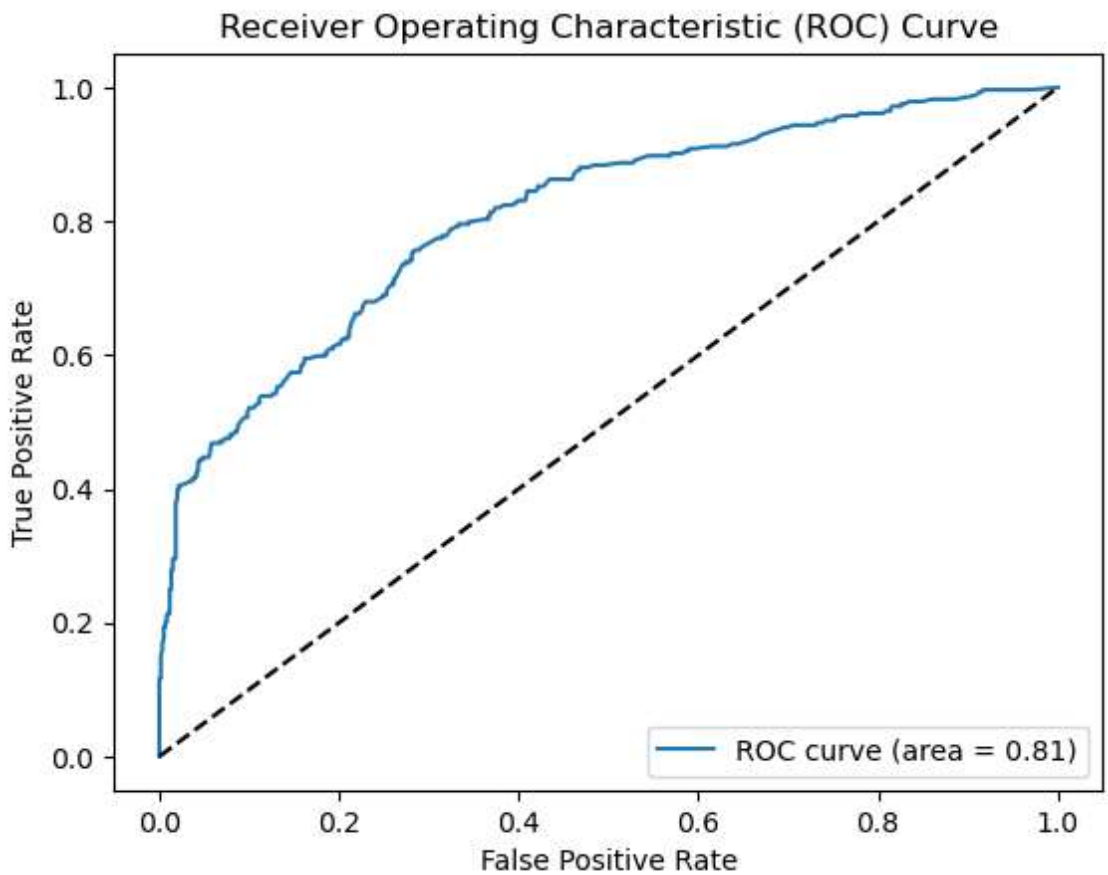
In [94]:

```
# Plot the probability distribution of predicted probabilities
sns.histplot(y_pred, kde=True)
plt.xlabel('Predicted Probability')
plt.ylabel('Frequency')
plt.title('Probability Distribution')
plt.show()
```



In [95]:

```
y_pred_proba = log_reg.predict_proba(X_test_scaled)[::,1]

# Calculate the false positive rate, true positive rate, and thresholds
fpr, tpr, thresholds = roc_curve(y_test, y_pred_proba)

# Calculate the area under the ROC curve (AUC)
auc = roc_auc_score(y_test, y_pred_proba)

# Plot ROC curve
plt.plot(fpr, tpr, label='ROC curve (area = %0.2f)' % auc)
plt.plot([0, 1], [0, 1], 'k--')  # Plot the diagonal line
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.legend(loc='lower right')
plt.show()
```

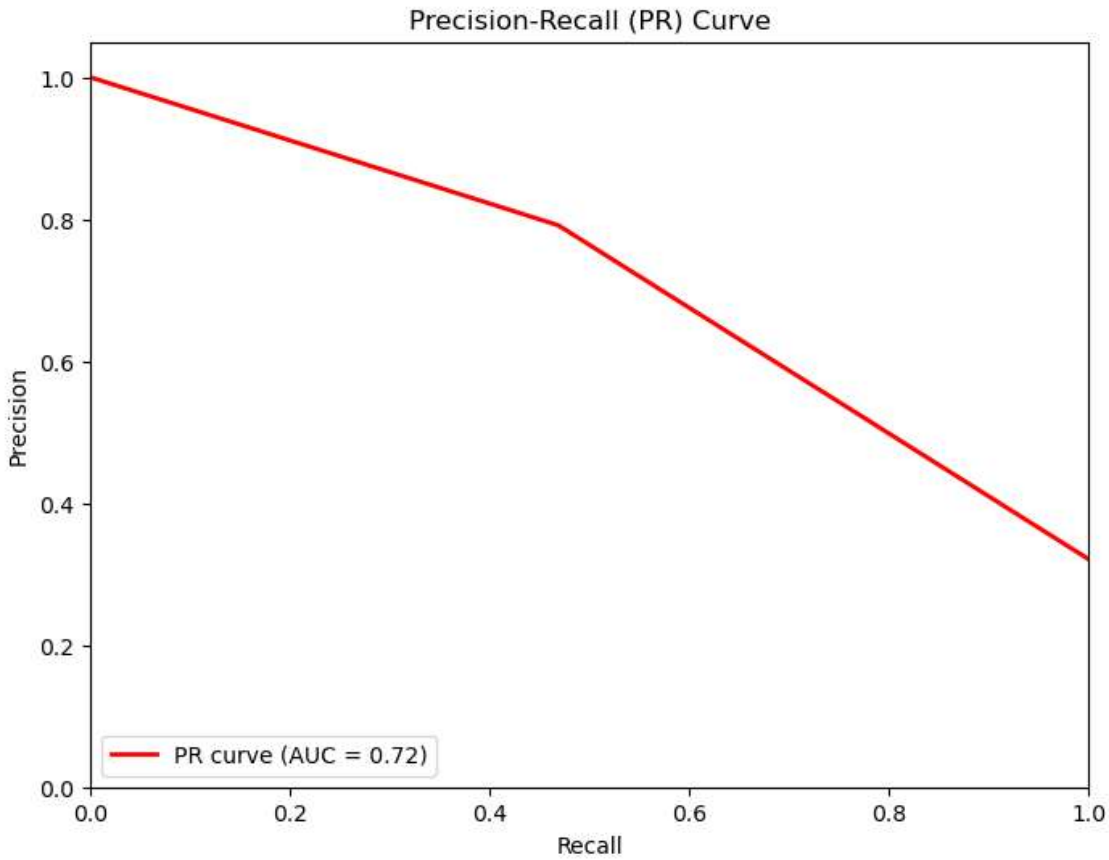


In [96]:

```
import matplotlib.pyplot as plt
from sklearn.metrics import roc_curve, roc_auc_score, precision_recall_cur
import numpy as np

# Assuming you have already trained your logistic regression model and obt

# Calculate ROC curve and AUC
fpr, tpr, _ = roc_curve(y_test, y_pred)
roc_auc = auc(fpr, tpr)

# Calculate Precision-Recall curve and AUC
precision, recall, _ = precision_recall_curve(y_test, y_pred)
pr_auc = auc(recall, precision)

# Calculate Gini coefficient (Lorentz curve)
lorentz_curve = np.cumsum(np.sort(y_test)[::-1]) / np.sum(y_test)
gini_coefficient = 2 * auc(np.linspace(0, 1, len(lorentz_curve)), lorentz_
```

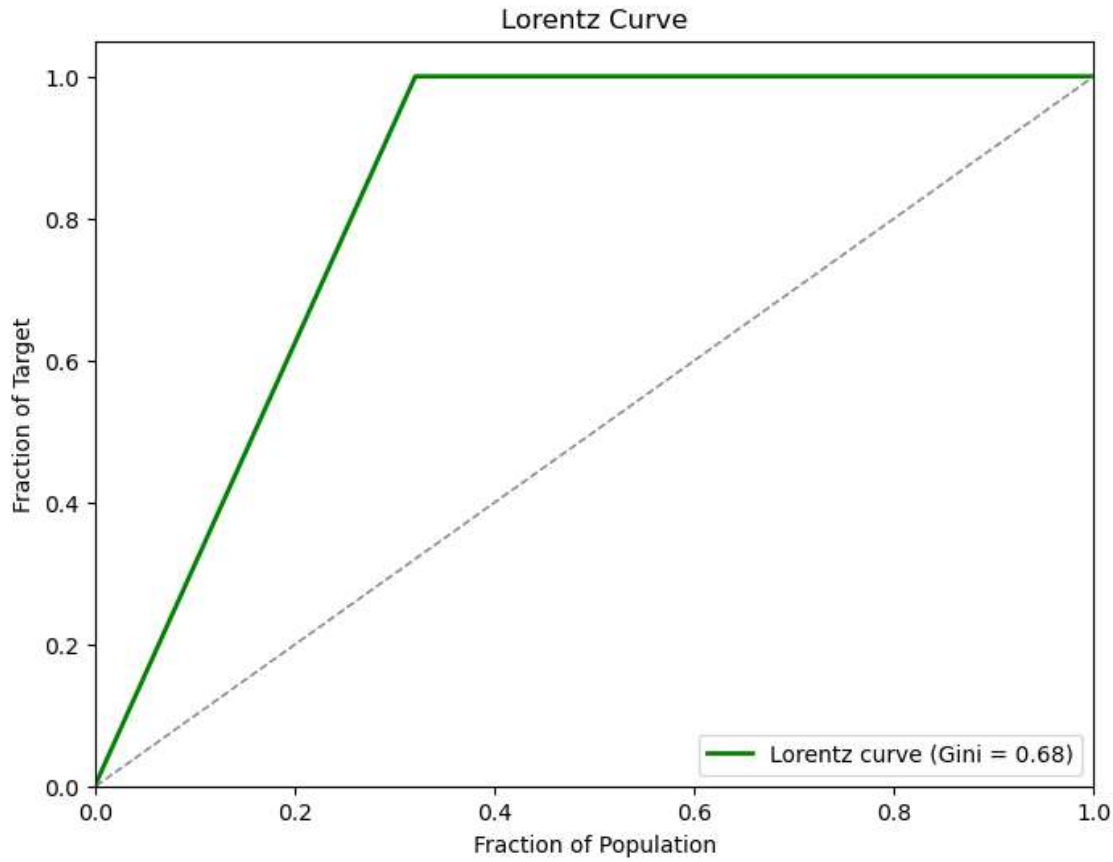
In [97]:

```
# Plot PR curve
plt.figure(figsize=(8, 6))
plt.plot(recall, precision, color='red', lw=2, label='PR curve (AUC = %0.2
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('Recall')
plt.ylabel('Precision')
plt.title('Precision-Recall (PR) Curve')
plt.legend(loc='lower left')
plt.show()
```



In [98]:

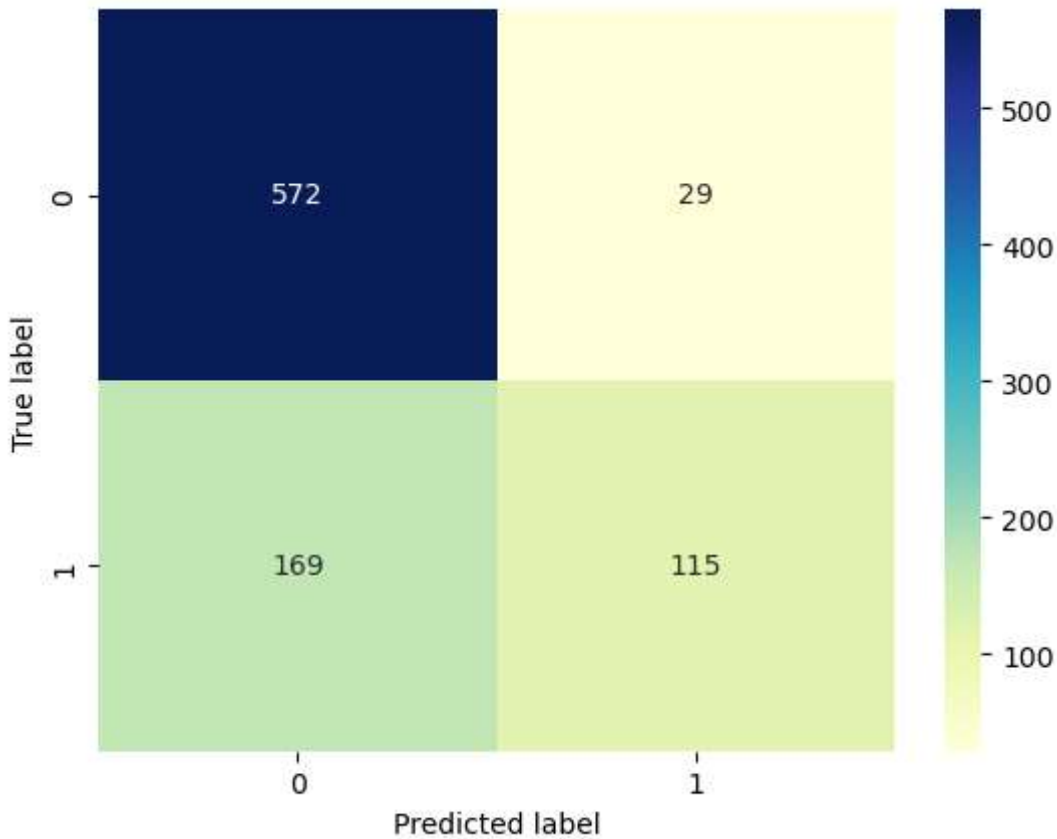
```
# Plot Lorentz curve
plt.figure(figsize=(8, 6))
plt.plot(np.linspace(0, 1, len(lorentz_curve)), lorentz_curve, color='gree
plt.plot([0, 1], [0, 1], color='gray', lw=1, linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('Fraction of Population')
plt.ylabel('Fraction of Target')
plt.title('Lorentz Curve')
plt.legend(loc='lower right')
plt.show()
```



SVM

In [99]:

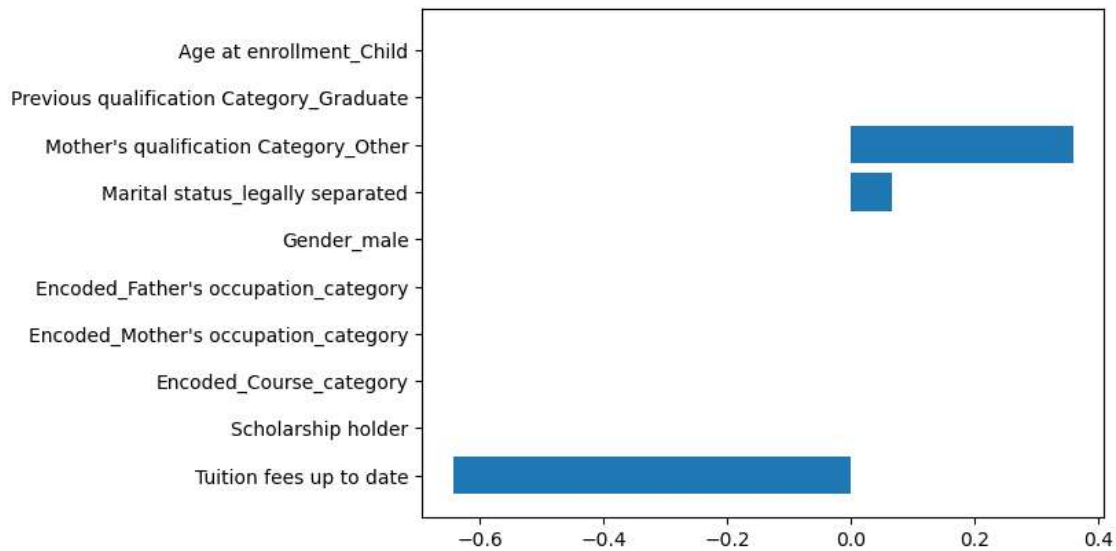
```
# Creating and fitting the SVM model
from sklearn.svm import SVC
svm_model = SVC(kernel='linear',probability=True, random_state=42)
svm_model.fit(X_train_scaled, y_train)

# Predicting on the test set
y_pred = svm_model.predict(X_test_scaled)

# Generate confusion matrix
cm = confusion_matrix(y_test, y_pred)

# Plot the confusion matrix as a heatmap
sns.heatmap(cm, annot=True, fmt='d', cmap='YlGnBu')
plt.xlabel('Predicted label')
plt.ylabel('True label')
plt.show()
```



In [100]:

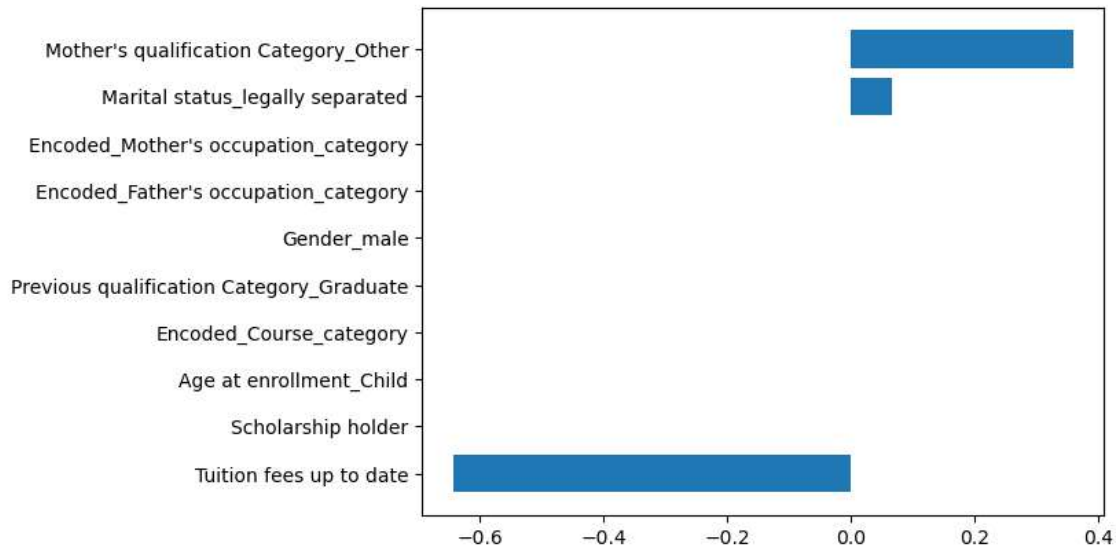
```
# Printing the SVM coefficients and feature names
print(svm_model.coef_)
print(X.columns)

# Plotting the SVM coefficients
plt.barh(X.columns, svm_model.coef_[0])
plt.show()
```

```
[[-6.42742791e-01 -5.74530637e-05  4.25119364e-06  3.02343147e-04
   3.72121983e-05  1.89105015e-05  6.72026021e-02  3.58783438e-01
   1.72460564e-05 -2.30340074e-05]]
Index(['Tuition fees up to date', 'Scholarship holder',
       'Encoded_Course_category', 'Encoded_Mother's occupation_category',
       'Encoded_Father's occupation_category', 'Gender_male',
       'Marital status_legally separated',
       'Mother's qualification Category_Other',
       'Previous qualification Category_Graduate', 'Age at enrollment_Chi
ld'],
      dtype='object')
```



In [101]:

```
def f_importances(coef, names):
    imp = coef
    imp, names = zip(*sorted(zip(imp, names)))
    plt.barh(range(len(names)), imp, align='center')
    plt.yticks(range(len(names)), names)
    plt.show()

# Plotting the feature importances
f_importances(svm_model.coef_[0], X.columns)
```



In [102]:

```
# Calculate accuracy
accuracy = accuracy_score(y_test, y_pred)
print("\n Accuracy of this Model is : ", accuracy)
```

```
 Accuracy of this Model is :  0.7762711864406779
```

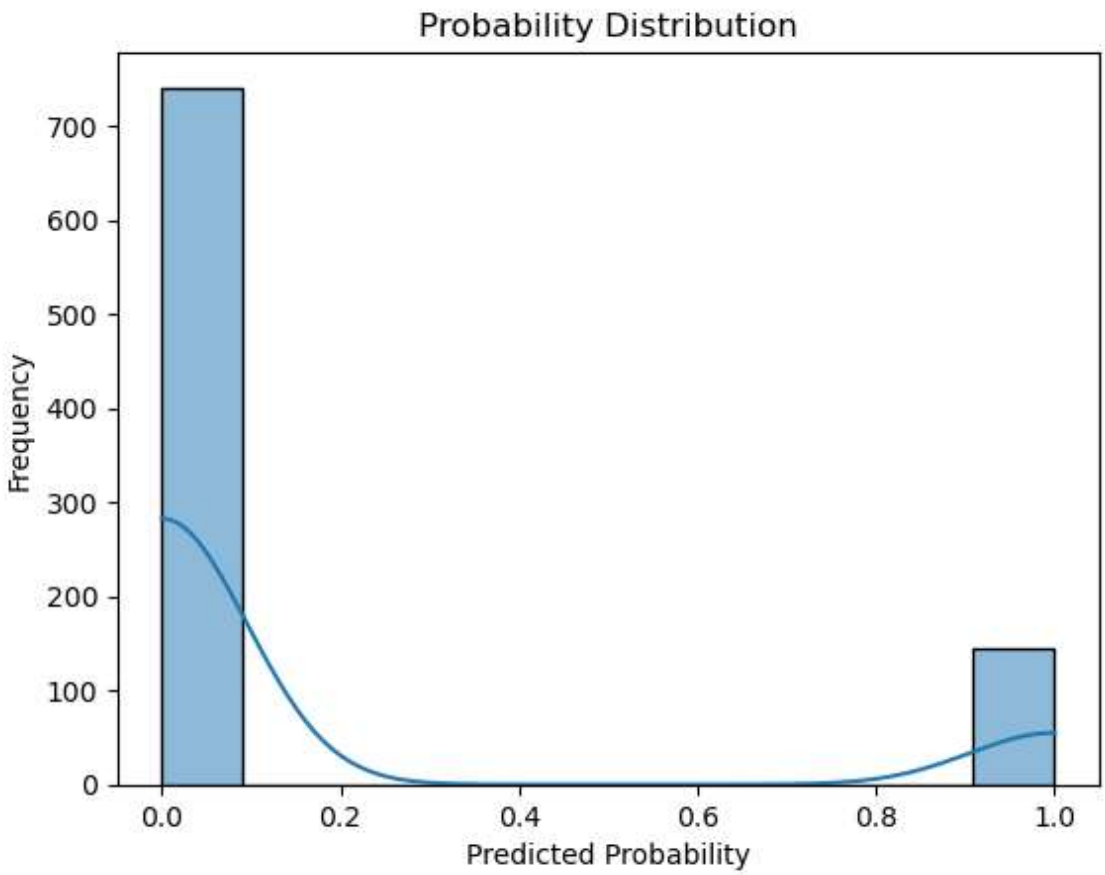
In [103]:

```
# Evaluating the model
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.77      0.95      0.85       601
           1       0.80      0.40      0.54       284

    accuracy                           0.78       885
   macro avg       0.79      0.68      0.69       885
weighted avg       0.78      0.78      0.75       885
```

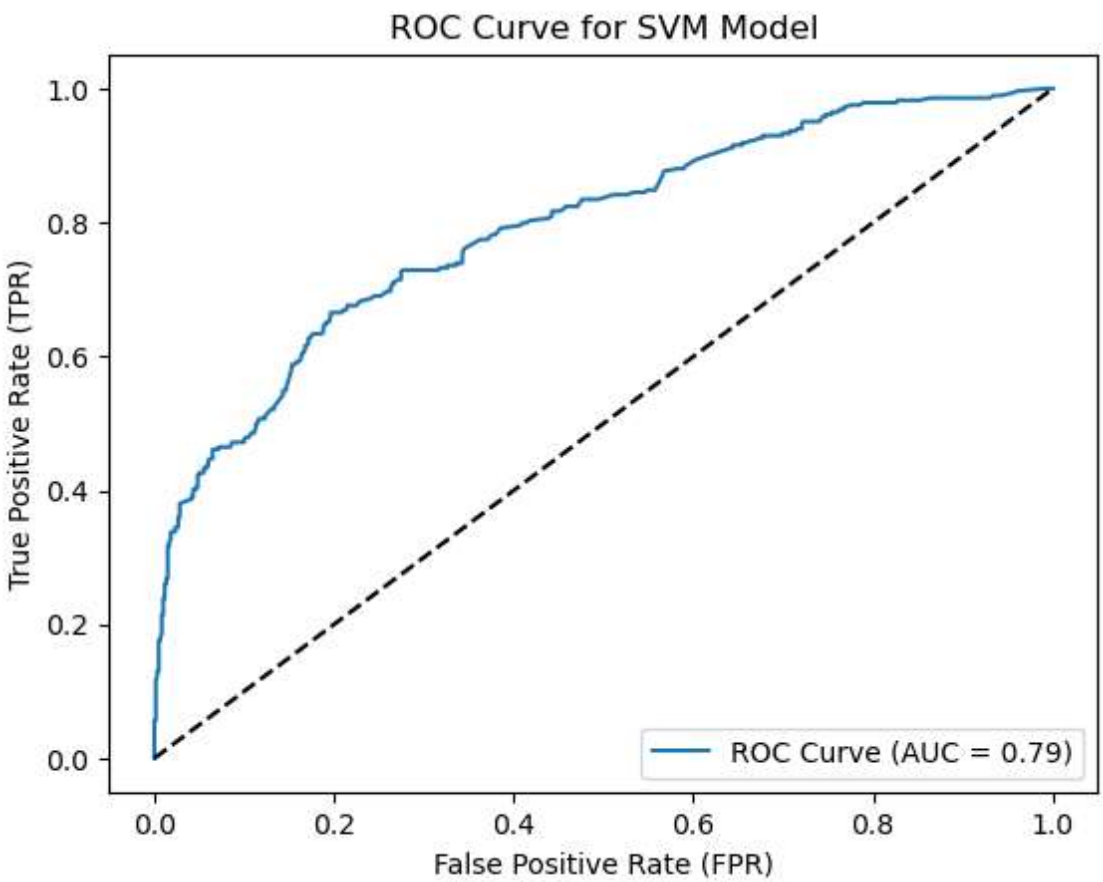
In [104]:

```
# Plot the probability distribution of predicted probabilities
sns.histplot(y_pred, kde=True)
plt.xlabel('Predicted Probability')
plt.ylabel('Frequency')
plt.title('Probability Distribution')
plt.show()
```



In [105]:

```
# Predict probabilities for the positive class (class 1)
y_probs = svm_model.predict_proba(X_test)[:, 1]

# Compute ROC curve
fpr, tpr, _ = roc_curve(y_test, y_probs)

# Compute ROC AUC
roc_auc = roc_auc_score(y_test, y_probs)

# Plot ROC curve
plt.figure()
plt.plot(fpr, tpr, label=f'ROC Curve (AUC = {roc_auc:.2f})')
plt.plot([0, 1], [0, 1], 'k--')  # Diagonal line representing random guess
plt.xlabel('False Positive Rate (FPR)')
plt.ylabel('True Positive Rate (TPR)')
plt.title('ROC Curve for SVM Model')
plt.legend(loc='lower right')
plt.show()
```



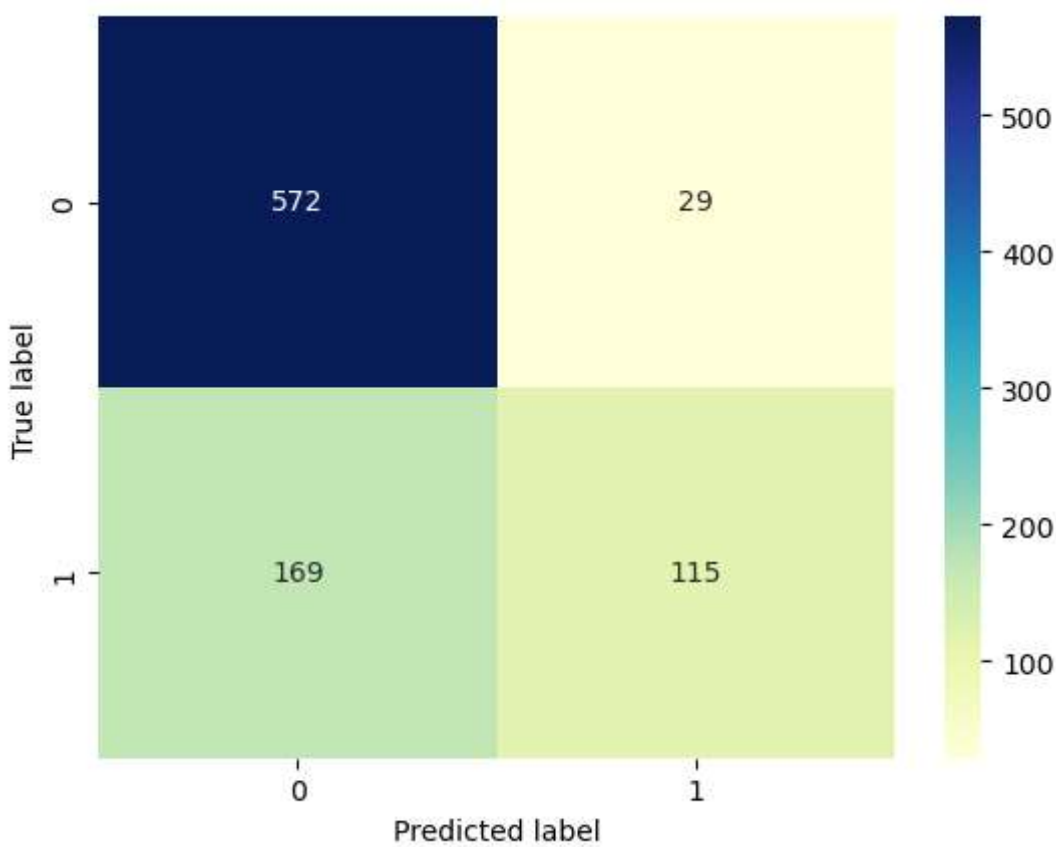
In [106]:

```
from sklearn.model_selection import GridSearchCV

# Select the optimal C parameter by cross-validation
tuned_parameters = [{'C': [0.001, 0.01, 1, 10,]}]
clf = GridSearchCV(SVC(kernel='linear'), tuned_parameters, cv=10, scoring=
clf.fit(X_train_scaled, y_train)

clf.cv_results_

clf.best_params_
```

Out[106]: {'C': 0.01}

In [107]:

```
# Creating and fitting the SVM model
svm_model = SVC(C=0.01,kernel='linear',probability=True, random_state=42)
svm_model.fit(X_train_scaled, y_train)

# Predicting on the test set
y_pred = svm_model.predict(X_test_scaled)

# Generate confusion matrix
cm = confusion_matrix(y_test, y_pred)

# Plot the confusion matrix as a heatmap
sns.heatmap(cm, annot=True, fmt='d', cmap='YlGnBu')
plt.xlabel('Predicted label')
plt.ylabel('True label')
plt.show()
```



In [108]:

```python
# Calculate accuracy
accuracy = accuracy_score(y_test, y_pred)
print("\n Accuracy of this Model is : ", accuracy)
```

```
 Accuracy of this Model is :  0.7762711864406779
```

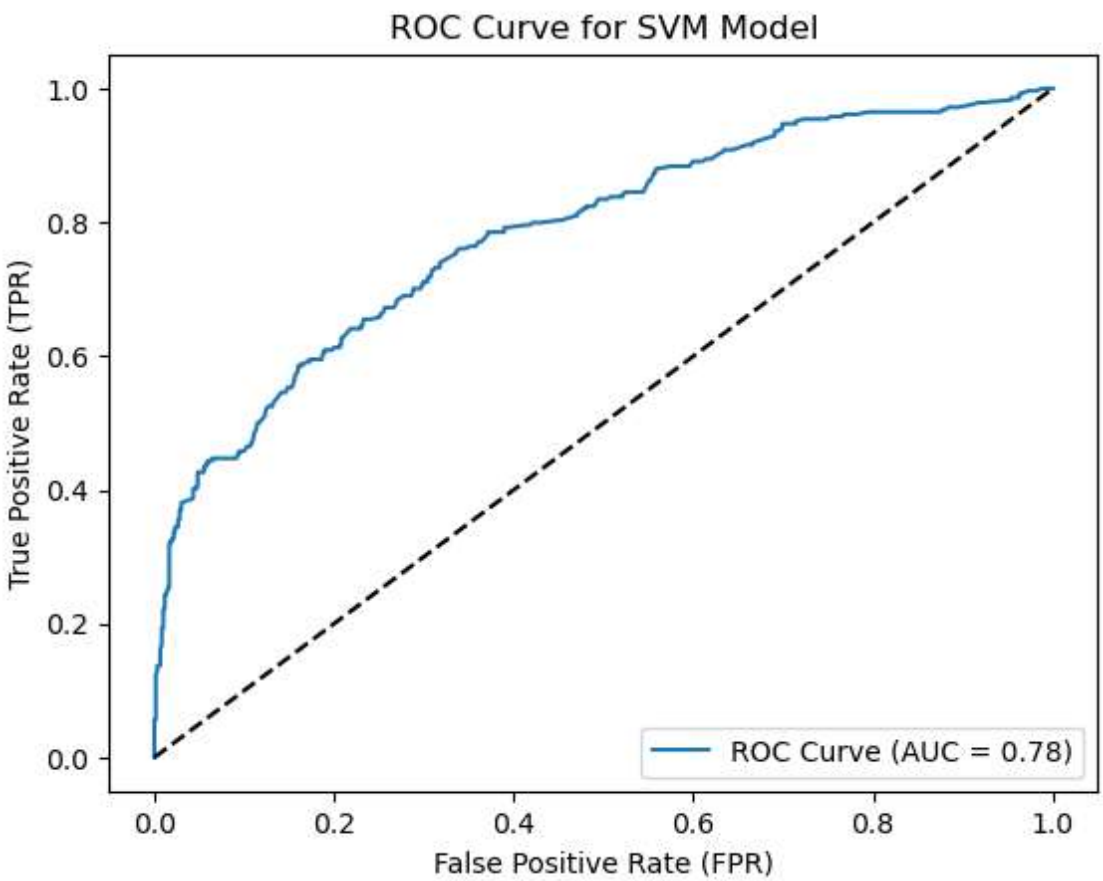
In [109]:

```python
# Evaluating the model
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.77      0.95      0.85       601
           1       0.80      0.40      0.54       284

    accuracy                           0.78       885
   macro avg       0.79      0.68      0.69       885
weighted avg       0.78      0.78      0.75       885
```

In [110]:

```
# Predict probabilities for the positive class (class 1)
y_probs = svm_model.predict_proba(X_test)[:, 1]

# Compute ROC curve
fpr, tpr, _ = roc_curve(y_test, y_probs)

# Compute ROC AUC
roc_auc = roc_auc_score(y_test, y_probs)

# Plot ROC curve
plt.figure()
plt.plot(fpr, tpr, label=f'ROC Curve (AUC = {roc_auc:.2f})')
plt.plot([0, 1], [0, 1], 'k--')  # Diagonal line representing random guess
plt.xlabel('False Positive Rate (FPR)')
plt.ylabel('True Positive Rate (TPR)')
plt.title('ROC Curve for SVM Model')
plt.legend(loc='lower right')
plt.show()
```



In [ ]: