ETL

March 5, 2023

In [1]:
```
! pip install -U numpy
! pip install missingno
```

```
Collecting numpy
  Downloading https://files.pythonhosted.org/packages/45/b2/6c7545bb7a38754d63048c7696804a0d9473
    100% || 13.4MB 1.4MB/s eta 0:00:01    24% |                          | 3.2MB 33.5MB/s eta 0:00:
tensorflow 1.3.0 requires tensorflow-tensorboard<0.2.0,>=0.1.0, which is not installed.
Installing collected packages: numpy
  Found existing installation: numpy 1.12.1
    Uninstalling numpy-1.12.1:
      Successfully uninstalled numpy-1.12.1
Successfully installed numpy-1.19.5
Collecting missingno
  Downloading https://files.pythonhosted.org/packages/87/22/cd5cf999af21c2f97486622c551ac3d07361
Requirement already satisfied: numpy in /opt/conda/lib/python3.6/site-packages (from missingno)
Requirement already satisfied: scipy in /opt/conda/lib/python3.6/site-packages (from missingno)
Requirement already satisfied: seaborn in /opt/conda/lib/python3.6/site-packages (from missingno
Requirement already satisfied: matplotlib in /opt/conda/lib/python3.6/site-packages (from missin
Requirement already satisfied: pandas in /opt/conda/lib/python3.6/site-packages (from seaborn->m
Requirement already satisfied: six>=1.10 in /opt/conda/lib/python3.6/site-packages (from matplot
Requirement already satisfied: python-dateutil>=2.0 in /opt/conda/lib/python3.6/site-packages (f
Requirement already satisfied: pytz in /opt/conda/lib/python3.6/site-packages (from matplotlib->
Requirement already satisfied: cycler>=0.10 in /opt/conda/lib/python3.6/site-packages/cycler-0.1
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in /opt/conda/lib/python
Installing collected packages: missingno
Successfully installed missingno-0.5.2
```

In [2]:
```
import pandas as pd
import matplotlib.pyplot as plt
import os
import configparser
import datetime as dt
from pyspark.sql.functions import isnan, when, count, col, udf, dayofmonth, dayofweek, m
from pyspark.sql.types import *
import requests
requests.packages.urllib3.disable_warnings()
from pyspark.sql.functions import year, month, dayofmonth, weekofyear, date_format
```

```
from pyspark.sql import SparkSession, SQLContext, GroupedData, HiveContext
from pyspark.sql.functions import *
from pyspark.sql.functions import date_add as d_add
from pyspark.sql.types import DoubleType, StringType, IntegerType, FloatType
from pyspark.sql import functions as F
from pyspark.sql.functions import lit
from pyspark.sql import Row
import datetime, time
import seaborn as sns
import numpy as np
import tools as tools
import tables_func as ct
import matplotlib.pyplot as plt
%matplotlib inline
```

0.1 Scope of the Project:

- In this project I will gather the data from two sources. I will load this data into staging dataframes. I will clean the raw data, write it to parquet files and perform an ETL process using a Spark cluster. Then I will write the data into Fact & Dimension tables to form a star schema. The star schema can then be used by the relevant parties to perform data analytics, correlation and ad-hoc reporting in an effective and efficient manner. ### Data Descriptions:
- Edu_ministry is Sample data of saudi scholarships students records from the Ministry of Education. This data source will serve as the Fact table in the schema. This data comes from https://od.data.gov.sa/Data/ar/group/education_and_training?page=2 :' '.
- Countries of the World :This dataset contains Country names linked to region, population, area size, GDP, mortality and more.

This data comes from Kaggle: https://www.kaggle.com/datasets/fernandol/countries-of-the-world

In [3]:
```
spark = SparkSession\
    .builder \
    .config("spark.jars.packages", "org.apache.hadoop:hadoop-aws:2.7.0") \
    .getOrCreate()
```

In [5]:
```
#import shutil

#shutil.rmtree('../Project/parquet_tables/countries')
```

Spark configuration parameters - ('spark.executor.id', 'driver'), - ('spark.app.name', 'pyspark-shell'), - ('spark.driver.port', '33753'), - ('spark.jars.packages', 'org.apache.hadoop:hadoop-aws:2.7.0'), - ('spark.rdd.compress', 'True'), - ('spark.serializer.objectStreamReset', '100'), - ('spark.master', 'local[*]'), - ('spark.driver.host', 'ad2cb8c219e1'), - ('spark.submit.deployMode', 'client'), - ('spark.jars',

In [6]:
```
fname = '../Project/Sources/Edu_minisrty.csv'
edu_df = pd.read_csv(fname)
```

```
In [7]: edu_df.head()
```

Out[7]:

0	2015.0			11.0		
1	2015.0			6.0		
2	2015.0					4.0
3	2015.0				3.0	
4	2015.0		1.0			

```
In [8]: fname = '../Project/Sources/countries of the world.csv'
        country_df = pd.read_csv(fname)
```

```
In [9]: country_df.head()
```

Out[9]:

	Country	Region	Population	Area (sq. mi.)	Pop.
0	Afghanistan	ASIA (EX. NEAR EAST)	31056997	647500	
1	Albania	EASTERN EUROPE	3581655	28748	
2	Algeria	NORTHERN AFRICA	32930091	2381740	
3	American Samoa	OCEANIA	57794	199	
4	Andorra	WESTERN EUROPE	71201	468	

	Infant mortality (per 1000 births)	GDP ($ per capita)	Literacy (%)	Phones (per 1000)
0	163,07	700.0	36,0	3,2
1	21,52	4500.0	86,5	71,2
2	31	6000.0	70,0	78,1
3	9,27	8000.0	97,0	259,5
4	4,05	19000.0	100,0	497,2

	Service
0	0,38
1	0,579
2	0,298
3	NaN
4	NaN

0.2 Exploration and Assessing the Data

Data Cleaning:

- Drop columns containing over 90% missing values
- Drop duplicate values

```
In [10]: # checking missing values
         edu_df.isnull().sum()
```

Out[10]:

```
0
 0
  0
0
```

```
                0
                       0
                       0
        dtype: int64
```

```
In [11]: # Drop columns with over 90% missing values
         clean_edu = tools.eliminate_missing_data(edu_df)
```

```
Dropping missing data...
Cleaning complete!
```

```
In [12]: clean_edu = tools.drop_duplicate_rows(clean_edu)
```

```
Dropping duplicate rows...
0 rows dropped.
```

```
In [13]: # Drop columns with over 90% missing values
         clean_country = tools.eliminate_missing_data(country_df)
```

```
Dropping missing data...
Cleaning complete!
```

```
In [14]: clean_country = tools.drop_duplicate_rows(clean_country)
```

```
Dropping duplicate rows...
0 rows dropped.
```

Now I'll translate the dataset to english language

```
In [15]: clean_edu = ct.translate_en(clean_edu)
         clean_edu.head()
```

```
Out[15]:    Academic_year    Country     Scholarship_type Educational_level
         0         2015.0  Australia  Scholarship student             Other                   Bus
         1         2015.0  Australia  Scholarship student             Other                   Bus
         2         2015.0  Australia  Scholarship student             Other
         3         2015.0  Australia  Scholarship student             Other
         4         2015.0  Australia  Scholarship student             Other  Natural sciences, m
```

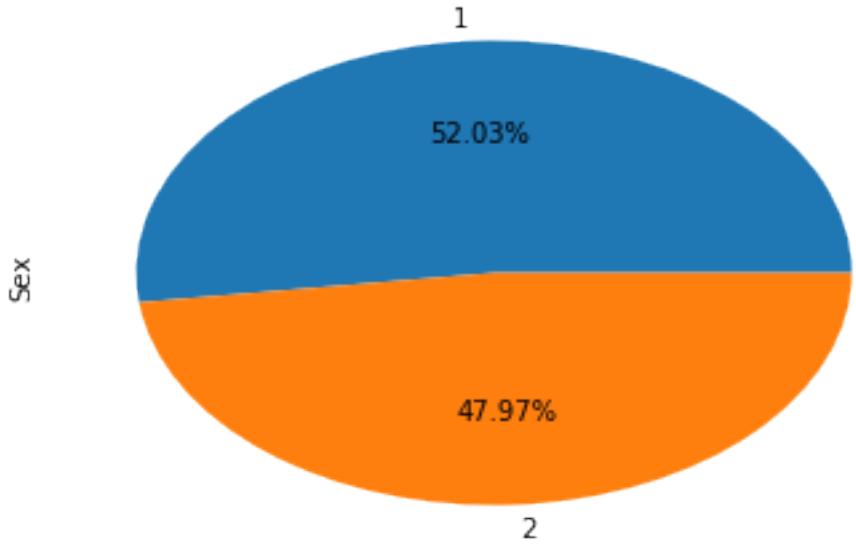
```
In [16]: clean_edu['Country'].count()
```

```
Out[16]: 3148
```

Males represent No.1 and females No.2

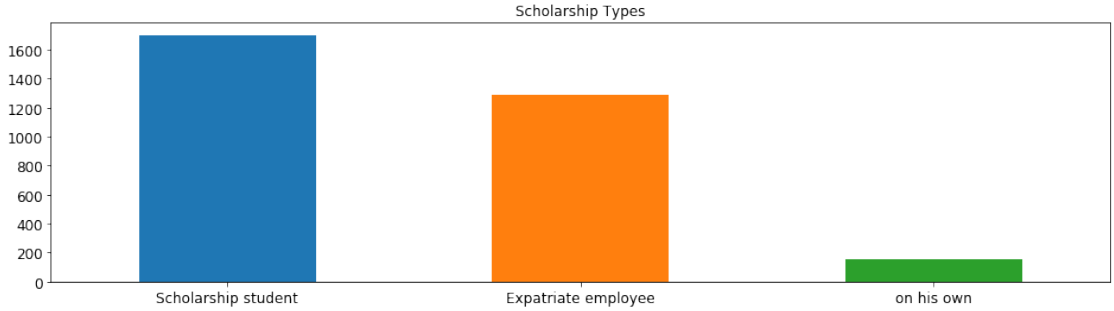
```
In [15]: clean_edu['Sex'].value_counts().plot(kind='pie',autopct='%.2f%%')
```

Out[15]: <matplotlib.axes._subplots.AxesSubplot at 0x7f501e43fda0>



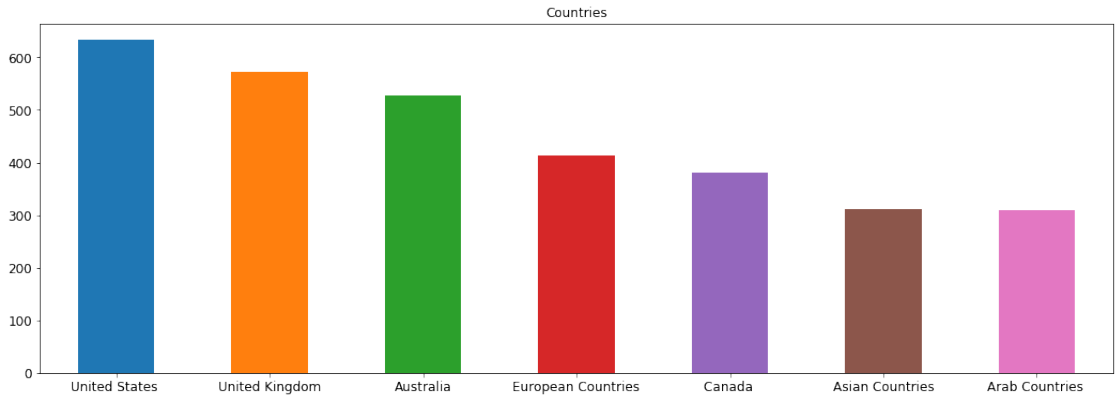
In [17]:
```
fig, ax = plt.subplots(figsize=(16,4))
clean_edu['Scholarship_type'].value_counts().plot(kind='bar', fontsize =12, rot = 0)
plt.title('Scholarship Types')
```

Out[17]: Text(0.5,1,'Scholarship Types')



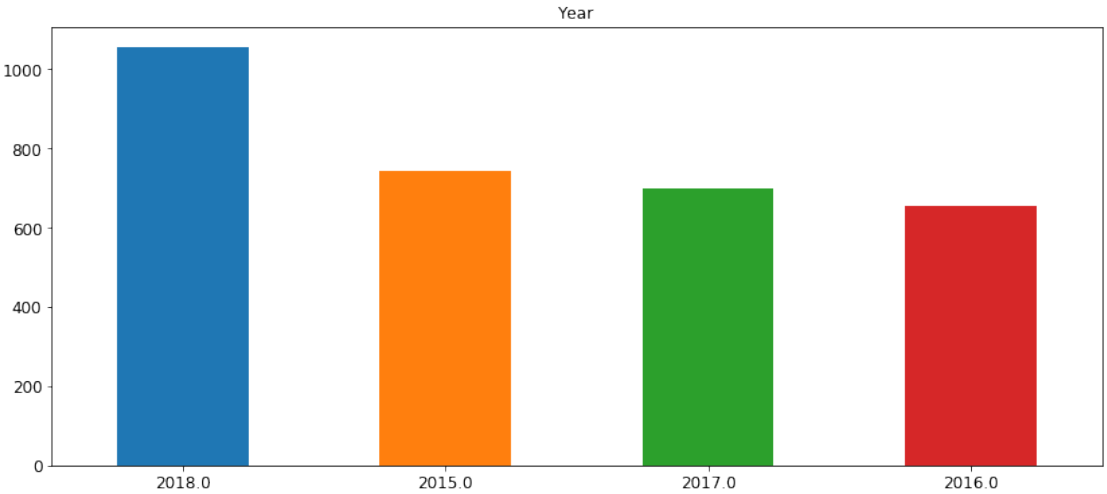
In [18]:
```
fig, ax = plt.subplots(figsize=(18,6))
clean_edu['Country'].value_counts().plot(kind='bar', fontsize =12, rot = 0)
plt.title('Countries')
```

Out[18]: Text(0.5,1,'Countries')



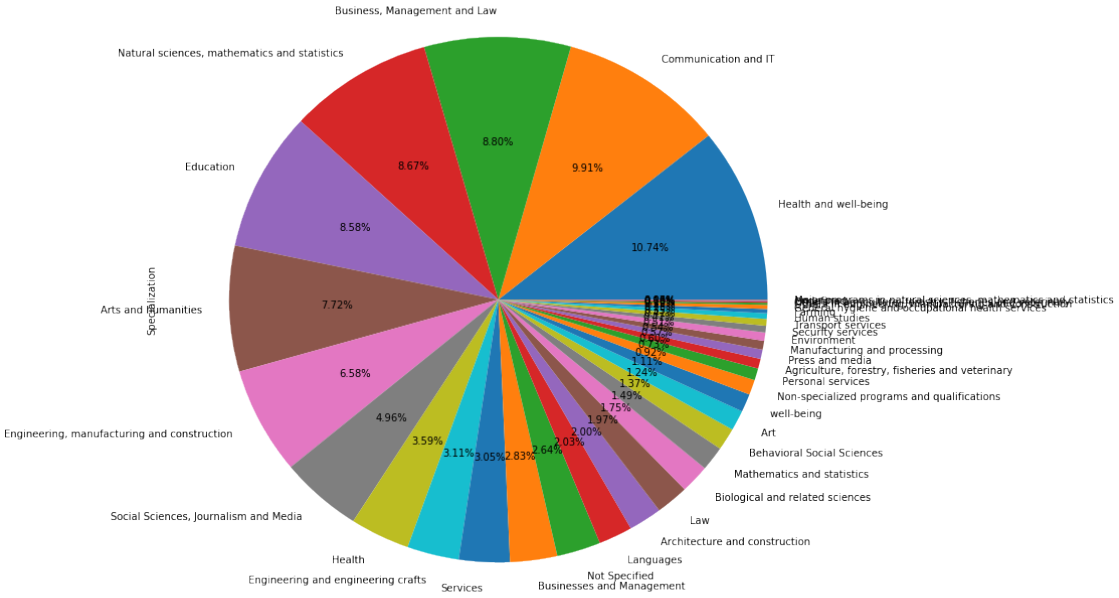
In [19]:
```
fig, ax = plt.subplots(figsize=(14,6))
clean_edu['Academic_year'].value_counts().plot(kind='bar', fontsize =12, rot = 0)
plt.title('Year')
```

Out[19]: Text(0.5,1,'Year')



In [20]:
```
fig, ax = plt.subplots(figsize=(12,12))
clean_edu['Specialization'].value_counts().plot(kind='pie',autopct='%.2f%%')
```

Out[20]: <matplotlib.axes._subplots.AxesSubplot at 0x7f6a26e11588>



0.3 Defining the Data Model

3.1 Conceptual Data Model In accordance with Kimball Dimensional Modelling Techniques, laid out in this document (http://www.kimballgroup.com/wp-content/uploads/2013/08/2013.09-Kimball-Dimensional-Modeling-Techniques11.pdf), the following modelling steps have been taken:

- Select the Business Process:
- The Scholarships department follows their business process of recording scholarships students. This process generates events which are captured and translated to facts in a fact table
- Declare the Grain:
- The grain identifies exactly what is represented in a single fact table row.
- In this project, the grain is declared as a single occurrence of a batch of scholarships students out of the KSA.
- Identify the Dimensions:
- Dimension tables provide context around an event or business process.
- The dimensions identified in this project are:
- dim_country
- dim_specialization
- Identify the Facts:
- Fact tables focus on the occurrences of a singular business process, and have a one-to-one relationship with the events described in the grain.
- The fact table identified in this project is:
- fact_scholarships

For this application, I have developed a set of Fact and Dimension tables in a Relational Database Management System to form a Star Schema. This Star Schema can be used by Data Analysts and other relevant business professionals to gain deeper insight into various scholarships figures, trends and statistics recorded historically.

3.2 Mapping Out Data Pipelines

List the steps necessary to pipeline the data into the chosen data model:

- 1 Load the data into staging tables
- 2 Create Dimension tables
- 3 Create Fact table
- 4 Write data into parquet files
- 5 Perform data quality checks

0.4 Running Pipelines to Model the Data

4.1 Create the data model Build the data pipelines to create the data model.

```
In [17]: output_path = "parquet_tables/"
```

```
In [18]: clean_edu.head()
```

```
Out[18]:    Academic_year    Country     Scholarship_type Educational_level
         0         2015.0  Australia  Scholarship student             Other                  Bus
         1         2015.0  Australia  Scholarship student             Other                  Bus
         2         2015.0  Australia  Scholarship student             Other
         3         2015.0  Australia  Scholarship student             Other
         4         2015.0  Australia  Scholarship student             Other  Natural sciences, m
```

```
In [19]: # creating schema
         scholarships_schema = StructType([StructField("Academic_year", StringType(), True)\
                                  ,StructField("Country", StringType(), True)\
                                  ,StructField("Scholarship_type", StringType(), True)\
                                  ,StructField("Educational_level", StringType(), True)\
                                  ,StructField("Specialization", StringType(), True)\
                                  ,StructField("Sex", StringType(), True)\
                                  ,StructField("Count", FloatType(), True)])

         scholarships_spark = spark.createDataFrame(clean_edu, schema=scholarships_schema)

         scholarships_spark.toPandas().head()
```

```
Out[19]:   Academic_year    Country     Scholarship_type Educational_level
         0        2015.0  Australia  Scholarship student             Other                  Busi
         1        2015.0  Australia  Scholarship student             Other                  Busi
         2        2015.0  Australia  Scholarship student             Other
         3        2015.0  Australia  Scholarship student             Other
         4        2015.0  Australia  Scholarship student             Other  Natural sciences, ma
```

In [31]:
```
clean_country.head()
```

Out[31]:

	Country	Region	Population	Area (sq. mi.)	Pop
0	Afghanistan	ASIA (EX. NEAR EAST)	31056997	647500	
1	Albania	EASTERN EUROPE	3581655	28748	
2	Algeria	NORTHERN AFRICA	32930091	2381740	
3	American Samoa	OCEANIA	57794	199	
4	Andorra	WESTERN EUROPE	71201	468	

	Infant mortality (per 1000 births)	GDP ($ per capita)	Literacy (%)	Phones (per 1000)
0	163,07	700.0	36,0	3,2
1	21,52	4500.0	86,5	71,2
2	31	6000.0	70,0	78,1
3	9,27	8000.0	97,0	259,5
4	4,05	19000.0	100,0	497,2

	Service
0	0,38
1	0,579
2	0,298
3	NaN
4	NaN

In [21]:
```
#"Country","Region","Population","Net migration","Coastline (coast/area ratio)","GDP ($
country_schema = StructType([StructField("Country", StringType(), True)\
                            ,StructField("Region", StringType(), True)\
                            ,StructField("Population", IntegerType(), True)\
                            ,StructField("Area (sq. mi.)", IntegerType(), True)\
                            ,StructField("Pop. Density (per sq. mi.)", StringType(), T
                            ,StructField("Coastline (coast/area ratio", StringType(),
                            ,StructField("Net migration)", StringType(), True)\
                            ,StructField("Infant mortality (per 1000 births)", StringT
                            ,StructField("GDP ($ per capita", FloatType(), True)
                           ,StructField("Literacy (%)", StringType(), True)\
                           ,StructField("Phones (per 1000)", StringType(), True)\
                           ,StructField("Arable (%)", StringType(), True)\
                           ,StructField("Crops (%)", StringType(), True)\
                           ,StructField("Other (%)", StringType(), True)\
                           ,StructField("Climate", StringType(), True)\
                           ,StructField("Birthrate", StringType(), True)\
                           ,StructField("Deathrate", StringType(), True)\
                           ,StructField("Agriculture", StringType(), True)\
                           ,StructField("ndustry", StringType(), True)\
                           ,StructField("Service", StringType(), True)])

country_spark = spark.createDataFrame(clean_country, schema=country_schema)

country_spark.toPandas().head()
```

Out[21]:

	Country	Region	Population	Area (sq. mi.)	Pop
0	Afghanistan	ASIA (EX. NEAR EAST)	31056997	647500	
1	Albania	EASTERN EUROPE	3581655	28748	
2	Algeria	NORTHERN AFRICA	32930091	2381740	
3	American Samoa	OCEANIA	57794	199	
4	Andorra	WESTERN EUROPE	71201	468	

	Infant mortality (per 1000 births)	GDP ($ per capita	Literacy (%)	Phones (per 1000)
0	163,07	700.0	36,0	3,2
1	21,52	4500.0	86,5	71,2
2	31	6000.0	70,0	78,1
3	9,27	8000.0	97,0	259,5
4	4,05	19000.0	100,0	497,2

	Service
0	0,38
1	0,579
2	0,298
3	NaN
4	NaN

In [22]:
```
# inserting missed rows
added_row = [['Arab Countries', 'MIDLE EAST',0,0,'','','','',0.0,'','','','','','','','','
        ,['Asian Countries', 'ASIA',0,0,'','','','',0.0,'','','','','','','','','','','
        ,['European Countries', 'EUROPE',0,0,'','','','',0.0,'','','','','','','','','','

# Creating the DataFrame
newRow = spark.createDataFrame(added_row,schema=None)
country_spark= country_spark.union(newRow)
```

1. Create dim_Country table

In [23]:
```
ct.create_country_dim(country_spark, output_path)
```

```
Writing table countries to parquet_tables/countries
Write complete!
```

Out[23]:
```
DataFrame[country_id: int, country_name: string, Region: string, Population: bigint, Co
```

In [24]:
```
country = spark.read.parquet("parquet_tables/countries")

country.toPandas().head()
```

Out[24]:

	country_id	country_name	Region	Population	Coastli
0	0	Afghanistan	ASIA (EX. NEAR EAST)	31056997	
1	1	Albania	EASTERN EUROPE	3581655	
2	2	Algeria	NORTHERN AFRICA	32930091	
3	3	American Samoa	OCEANIA	57794	
4	4	Andorra	WESTERN EUROPE	71201	

2. Create dim_Specialization table

```
In [25]: ct.create_specialization_dim(scholarships_spark, output_path)

Writing table specializations to parquet_tables/specializations
Write complete!


Out[25]: DataFrame[spec_id: int, spec_desc: string]

In [41]: specialization = spark.read.parquet("parquet_tables/specializations")

         specialization.toPandas().head()
```

	spec_id	spec_desc
0	0	Services
1	1	Engineering, manufacturing and construction
2	2	Education
3	3	Farming
4	4	Others in engineering, manufacturing and const...

3. Create fact_Scholarships table

```
In [27]: scholarships = ct.create_scholarships_fact(scholarships_spark, output_path, spark)

Writing table scholarships to parquet_tables/scholarships
Write complete!


In [28]: scholarships = spark.read.parquet("parquet_tables/scholarships")

         scholarships.toPandas().head()
```

	scholarships_id	spec_id	country_id	Academic_year	Educational_level	Sex	Count
0	0	0	228	2015.0	Other	1	30.0
1	1	33	228	2015.0	Other	2	1.0
2	2	33	228	2015.0	Other	1	1.0
3	3	1	228	2015.0	Other	1	2.0
4	4	16	228	2015.0	Fellowship	1	2.0

```
In [29]: scholarships.count()

Out[29]: 1738
```

0.5 Data Quality Checks

```
In [5]: tables = {
            "specialization": specialization,
            "country": country,
            "scholarships": scholarships
```

```
        }

        for table_name, table in tables.items():
            tools.perform_quality_check(table, table_name)


        ---------------------------------------------------------------------------

        NameError                                 Traceback (most recent call last)

        <ipython-input-5-56fc45cfc6ef> in <module>()
          1 tables = {
    ----> 2     "specialization": specialization,
          3     "country": country,
          4     "scholarships": scholarships
          5 }


        NameError: name 'specialization' is not defined
```

```
In [6]: countriesTable = spark.read.parquet("parquet_tables/countries")
        specializationTable = spark.read.parquet("parquet_tables/specializations")
        scholarshipsTable = spark.read.parquet('parquet_tables/scholarships')
```

```
In [30]: #Females
         scholarshipsTable.filter(scholarshipsTable.Sex == '2') \
                          .select('scholarships_id', 'Sex') \
                          .dropDuplicates() \
                          .count()
```

```
Out[30]: 828
```

```
In [31]: # Males
         scholarshipsTable.filter(scholarshipsTable.Sex == '1') \
                          .select('scholarships_id', 'Sex') \
                          .dropDuplicates() \
                          .count()
```

```
Out[31]: 910
```

```
In [25]: query = scholarshipsTable.select(["*"])\
                          .join(countriesTable, (countriesTable.country_id == scholarshipsTable.c
                          .join(specializationTable, (specializationTable.spec_id == scholarships
                          .select(['scholarships_id' ,specializationTable.spec_desc.alias('Specia
                                  'Sex', 'Educational_level','Academic_year','count'])\
                          .filter(countriesTable.country_name != ('Asian Countries'))\
                          .filter(countriesTable.country_name != ('European Countries'))\
                          .filter(countriesTable.country_name != ('Arab Countries'))
         query.toPandas().head(50)
```

Out[25]:

	scholarships_id	Specialization Name	Country Name	Coun
0	170	Business, Management and Law	United States	
1	171	Business, Management and Law	United States	
2	172	Education	United States	
3	173	Education	United States	
4	174	Health and well-being	United States	
5	175	Arts and humanities	United States	
6	176	Arts and humanities	United States	
7	177	Engineering, manufacturing and construction	United States	
8	178	Communication_IT	United States	
9	179	Communication_IT	United States	
10	180	Not Specified	United States	
11	181	Not Specified	United States	
12	182	Health and well-being	United States	
13	183	Health and well-being	United States	
14	184	Not Specified	United States	
15	185	Business, Management and Law	United States	
16	186	Business, Management and Law	United States	
17	187	Non-specialized programs and qualifications	United States	
18	188	Education	United States	
19	189	Education	United States	
20	190	Services	United States	
21	191	Services	United States	
22	192	Health and well-being	United States	
23	193	Health and well-being	United States	
24	194	Social Sciences, Journalism and Media	United States	
25	195	Social Sciences, Journalism and Media	United States	
26	196	Natural sciences, mathematics and statistics	United States	
27	197	Natural sciences, mathematics and statistics	United States	
28	198	Arts and humanities	United States	
29	199	Arts and humanities	United States	
30	200	Engineering, manufacturing and construction	United States	
31	201	Engineering, manufacturing and construction	United States	
32	202	Communication_IT	United States	
33	203	Communication_IT	United States	
34	204	Not Specified	United States	
35	205	Not Specified	United States	
36	206	Business, Management and Law	United States	
37	207	Business, Management and Law	United States	
38	208	Education	United States	
39	209	Education	United States	
40	210	Health and well-being	United States	
41	211	Health and well-being	United States	
42	212	Social Sciences, Journalism and Media	United States	
43	213	Social Sciences, Journalism and Media	United States	
44	214	Natural sciences, mathematics and statistics	United States	
45	215	Natural sciences, mathematics and statistics	United States	
46	216	Arts and humanities	United States	

```
47              217                          Arts and humanities  United States
48              218  Engineering, manufacturing and construction  United States
49              219  Engineering, manufacturing and construction  United States
```

In [ ]: