Exploratory Data Analysis on Online Course Enrollment Data

Estimated time needed: **45** minutes

Before we keep our heads down building a cool personalized online courses recommender system, we always need to take a look at data first since it is the essence of any machine learning system. We need to explore what kind of data we will need and what such data would look like.

You have already learned it is important to perform initial investigations on the data and how to perform exploratory data analysis to find preliminary insights such as data patterns and to check assumptions with the help of summary statistics and graphical representations.

Now, let's apply your EDA skills to online courses related datasets such as course titles/genres and course enrollments.

Objectives

After completing this lab you will be able to:

- Identify keywords in course titles using a WordCloud
- Calculate the summary statistics and visualizations of the online course content dataset
- Determine popular course genres
- Calculate the summary statistics and create visualizations of the online course enrollment dataset
- Identify courses with the greatest number of enrolled students

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Prepare and setup the lab environment

At the beginning, we need to install two required Python packages:

In [1]:
```
!pip install seaborn
!pip install wordcloud
!pip install pandas
!pip install matplotlib
```

```
Collecting seaborn
  Downloading seaborn-0.13.2-py3-none-any.whl.metadata (5.4 kB)
Collecting numpy!=1.24.0,>=1.20 (from seaborn)
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Collecting contourpy>=1.0.1 (from matplotlib!=3.6.1,>=3.4->seaborn)
  Downloading contourpy-1.3.3-cp312-cp312-manylinux_2_27_x86_64.manylinux_2_28_x8
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tools, cycler, pandas, contourpy, matplotlib, seaborn
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1.4.9 matplotlib-3.10.8 numpy-2.4.1 pandas-2.3.3 pillow-12.1.0 pyparsing-3.3.1 se
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_64.manylinux_2_28_x86_64.whl.metadata (3.4 kB)
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4.manylinux_2_28_x86_64.whl (555 kB)
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s (from python-dateutil>=2.7->matplotlib) (1.17.0)
```

and import necessary class/methods in the packages

In [2]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from wordcloud import WordCloud, STOPWORDS, ImageColorGenerator

%matplotlib inline
```

In [3]:
```
# also set a random state
rs = 123
```

Load and explore the dataset

First, let's load the datasets as `Pandas` dataframes and start some basic exploratory data analysis tasks on them.

In [4]:
```
# Point to the datasets stored on the cloud
course_genre_url = "https://cf-courses-data.s3.us.cloud-object-storage.appdomain
ratings_url = "https://cf-courses-data.s3.us.cloud-object-storage.appdomain.clou
```

In [5]:
```
course_df = pd.read_csv(course_genre_url)
ratings_df = pd.read_csv(ratings_url)
```

We will start by exploring the course genre dataset. Let's first check its columns/features name:

In [7]:
```
course_df.columns
```

Out[7]:
```
Index(['COURSE_ID', 'TITLE', 'Database', 'Python', 'CloudComputing',
       'DataAnalysis', 'Containers', 'MachineLearning', 'ComputerVision',
       'DataScience', 'BigData', 'Chatbot', 'R', 'BackendDev', 'FrontendDev',
       'Blockchain'],
      dtype='object')
```

We can see from the above cell output that the columns represent some metadata about a course such as its id, title, and genres. We can see that the course genres are some popular topics related to machine learning, databases, app developments, etc.

We can also check how many unique courses we have in this dataset:

In [8]:
```
course_df.shape[0]
```

Out[8]: 307

Then we can take a quick look at its header rows

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

Out[9]:

	COURSE_ID	TITLE	Database	Python	CloudComputing	DataAnalysis	Cont
0	ML0201EN	robots are coming build iot apps with watson ...	0	0	0	0	
1	ML0122EN	accelerating deep learning with gpu	0	1	0	0	
2	GPXX0ZG0EN	consuming restful services using the reactive ...	0	0	0	0	
3	RP0105EN	analyzing big data in r using apache spark	1	0	0	1	
4	GPXX0Z2PEN	containerizing packaging and running a sprin...	0	0	0	0	

In [10]:
```
course_df.dtypes
```

Out[10]:
```
COURSE_ID          object
TITLE              object
Database            int64
Python              int64
CloudComputing      int64
DataAnalysis        int64
Containers          int64
MachineLearning     int64
ComputerVision      int64
DataScience         int64
BigData             int64
Chatbot             int64
R                   int64
BackendDev          int64
FrontendDev         int64
Blockchain          int64
dtype: object
```

As we can see, the `COURSE_ID` and `TITLE` are `str` datatypes and all the course genres are binary/int datatypes. Any genre column with value 1 means the course is associated with the course genre while 0 means the course is not.

For example, the following course `accelerating deep learning with gpu` is associated with genres `Python`, `MachineLearning`, and `DataScience`

In [11]:
```
course_df.iloc[1, ]
```

Out[11]:
```
COURSE_ID                                      ML0122EN
TITLE              accelerating deep learning with gpu
Database                                             0
Python                                               1
CloudComputing                                       0
DataAnalysis                                         0
Containers                                           0
MachineLearning                                      1
ComputerVision                                       0
DataScience                                          1
BigData                                              0
Chatbot                                              0
R                                                    0
BackendDev                                           0
FrontendDev                                          0
Blockchain                                           0
Name: 1, dtype: object
```

Next, let's focus on the course title column by trying to determine keywords in the titles. Those keywords in the titles may give us a more intuitive summary of what kind of courses we have in the dataset.

Plot a Word Cloud from Course Titles

First, let's join all the title values into one string, then we can conveniently get a wordcloud from the big string:

In [12]:
```
titles = " ".join(title for title in course_df['TITLE'].astype(str))
```

In [13]:
```
titles
```

Out[13]: 'robots are coming build iot apps with watson swift and node red acceleratin
g deep learning with gpu consuming restful services using the reactive jax rs c
lient analyzing big data in r using apache spark containerizing packaging and
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with javascript and jquery'
```

We also want to filter common stop words and some less meaningful words:

In [14]:
```
# English Stopwords
stopwords = set(STOPWORDS)
stopwords.update(["getting started", "using", "enabling", "template", "universit
```

Then, we create a `WordCloud` object and generate `wordcloud` from the titles.

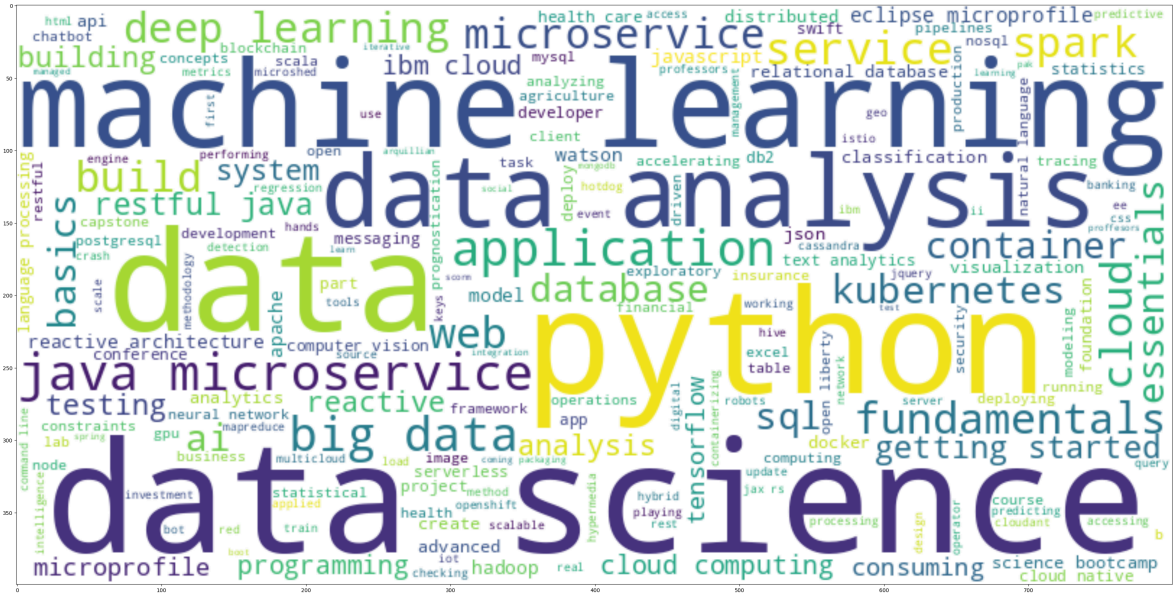
In [15]:
```
wordcloud = WordCloud(stopwords=stopwords, background_color="white", width=800,
```

In [16]:
```
wordcloud.generate(titles)
```

Out[16]:
```
<wordcloud.wordcloud.WordCloud at 0x728441841e50>
```

We can use `plt.imshow()` method to visualize the generated wordcloud:

In [17]:
```
# Disable axis display
plt.axis("off")
# Create a new figure with a specified size
plt.figure(figsize=(40,20))
# Adjust the layout to ensure tight spacing
plt.tight_layout(pad=0)
# Display the word cloud image with bilinear interpolation
plt.imshow(wordcloud, interpolation='bilinear')
# Show the plot
plt.show()
```



As we can see from the `wordcloud`, there are many popular IT related keywords such as python, data science, machine learning, big data, ai, tensorflow, container, cloud, etc. By looking at these keywords, we should have a general understanding that the courses in the dataset are focused on demanding IT skills.

Next, you need to perform some more detailed analysis on the course dataset.

TASK: Analyze Course Genres

First, you can try to find out which courses may be of interest you. For example, what are the all machine learning related courses?

TODO: Find all courses with genre `MachineLearning` == 1

In [23]:
```
# WRITE YOUR CODE HERE

ml_courses = course_df['MachineLearning']==1
print(ml_courses)
```

```
0      False
1       True
2      False
3      False
4      False
       ...
302    False
303    False
304    False
305    False
306    False
Name: MachineLearning, Length: 307, dtype: bool
```

▶ Click here for Hints

Similarly, you can try to find out what are the scalable machine learning courses?

TODO: Find all courses with genres `MachineLearning` == 1 and `BigData` == 1

In [25]:
```
# WRITE YOUR CODE HERE
ml_courses = course_df['BigData']==1
print(ml_courses)
```

```
0      False
1      False
2      False
3       True
4      False
       ...
302    False
303    False
304    False
305    False
306    False
Name: BigData, Length: 307, dtype: bool
```

▶ Click here for Hints

In [26]:
```
genres = course_df.columns[2:]
genres
```

Out[26]:
```
Index(['Database', 'Python', 'CloudComputing', 'DataAnalysis', 'Containers',
       'MachineLearning', 'ComputerVision', 'DataScience', 'BigData',
       'Chatbot', 'R', 'BackendDev', 'FrontendDev', 'Blockchain'],
      dtype='object')
```

Given all the course genres, now let's calculate the course count for each genre. e.g., there are 69 courses that belong to the `MachineLearning` genre and 23 courses that belong to the `Python` genre. We also want to sort the genre count list to find the most popular course genres.

TODO: Use the Pandas dataframe sum() and sort_values() methods to genreate a sorted course count per genre. You may also implement the task with different solutions

In [41]:
```
## WRITE YOUR CODE HERE
genre_sums = course_df[genres].sum()
genre_df = pd.DataFrame(genre_sums,columns=['Count'])
genre_df = genre_df.sort_values(by="Count",ascending=False)
print(genre_df)
```

```
                Count
BackendDev         78
MachineLearning    69
Database           60
DataAnalysis       56
DataScience        38
CloudComputing     37
BigData            36
Python             28
FrontendDev        19
Containers         17
R                  17
ComputerVision     10
Chatbot             4
Blockchain          4
```

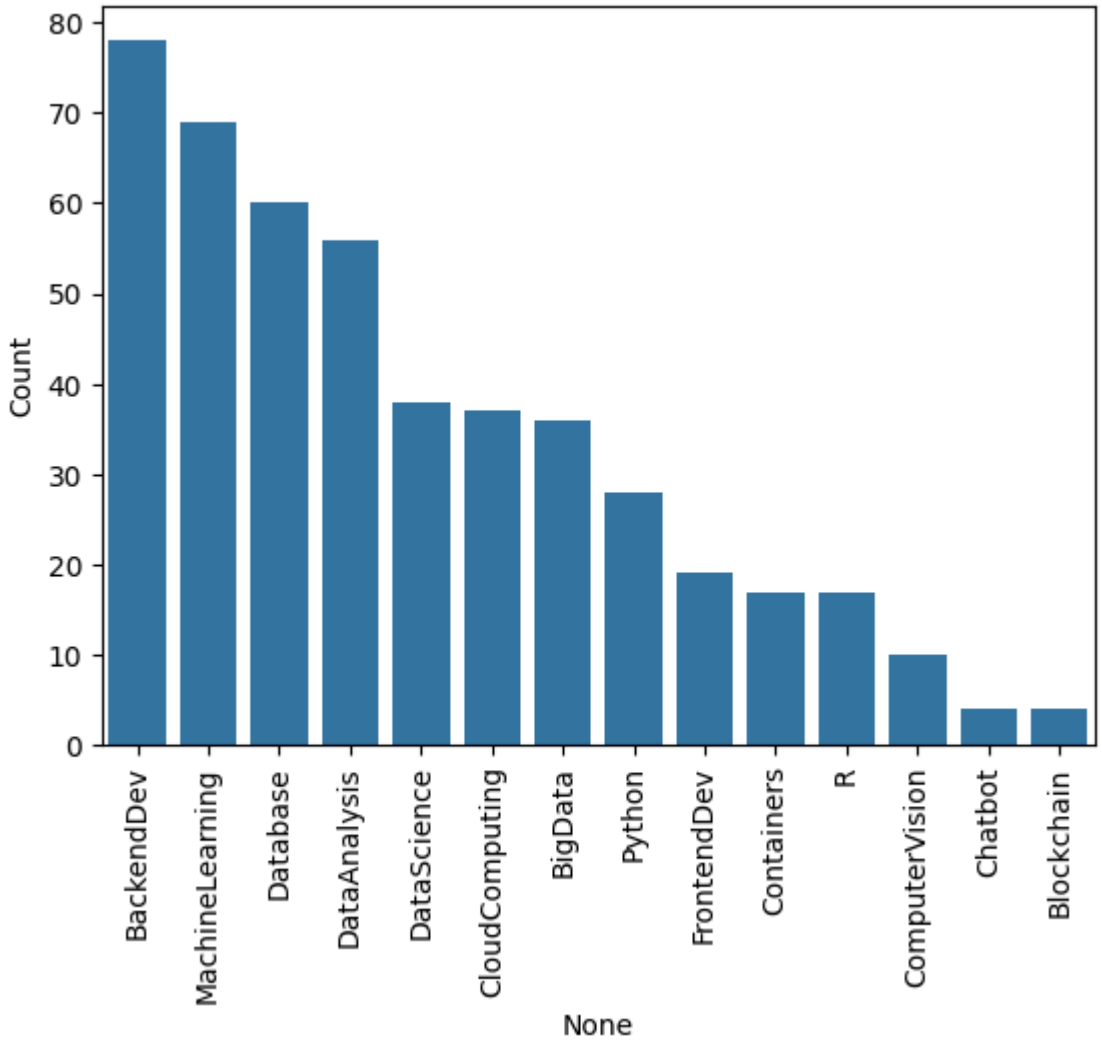
▶ Click here for Hints

We can also visualize course genre counts using a bar chart:

TODO: Use seaborn barplot or other plot methods to plot course genre counts using a barchart. The x-axis is the course genre and the y-axis is the course count per genre.

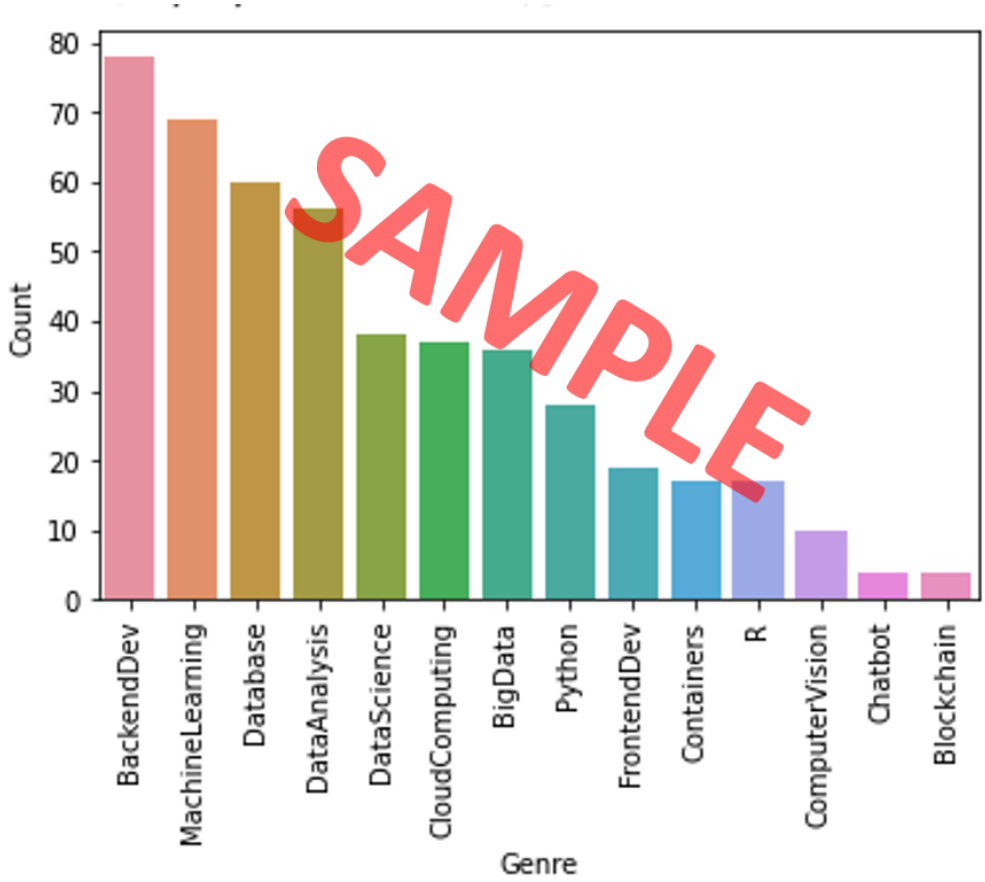
In [48]:
```
# WRITE YOUR CODE HERE
plot = sns.barplot(x=genre_df.index,y='Count', data=genre_df)
plot.set_xticklabels(plot.get_xticklabels(),rotation = 90)
plt.show()
```

```
/tmp/ipykernel_300/3204562845.py:3: UserWarning: set_ticklabels() should only be
used with a fixed number of ticks, i.e. after set_ticks() or using a FixedLocato
r.
  plot.set_xticklabels(plot.get_xticklabels(),rotation = 90)
```



▶ Click here for Hints

Your course genre barchart may look like the following:



Now, you should have some solid understanding about all course metadata including the keywords in titles and popular course genres. Next, we will switch gears to exploring course learners related datasets.

TASK: Analyze Course Enrollments

Let's first take a look at the course enrollments dataset.

In [49]:
```
ratings_df.head()
```

Out[49]:

	user	item	rating
0	1889878	CC0101EN	5
1	1342067	CL0101EN	3
2	1990814	ML0120ENv3	5
3	380098	BD0211EN	5
4	779563	DS0101EN	3

This dataset contains three colums, `user` representing a unique user id, `item` representing a course id, and `rating` representing the ratings given by the user.

In [50]:
```
ratings_df['rating'].unique()
```

Out[50]:
```
array([5, 3, 4])
```

The **rating** column consists of three potential values:

- A rating of `5` signifies that users who have enrolled in the course find it excellent and have given it the highest rating, thus recommending it to other learners.
- A rating of `4`, indicates that the enrolled users perceive the course as good and will recommend to the other learners,but suggest minor improvements.
- A rating of `3` indicates that enrolled users find the course below expectations and need significant modifications.

Let's see how many ratings we have in the dataset:

In [51]:
```
ratings_df.shape[0]
```

Out[51]:
```
233306
```

We have 233306 enrollments. In fact, each user is likely to interact with multiple items so let's find the rating counts for each user:

TODO: Apply Pandas' groupby() and size() method on the user column to aggregate the rating count for each user, then report the total number of users after aggregation.

In [55]:
```
# WRITE YOUR CODE HERE
ratings_df.groupby('user').size()
```

Out[55]:
```
user
2          61
4          44
5          59
7           1
8           3
          ..
2102054     8
2102356     1
2102680    11
2102983     1
2103039     1
Length: 33901, dtype: int64
```

▶ Click here for Hints

After the aggregation, you should get a new dataframe showing the rating count for each user. For example, user 4 rated 44 items and user 2 rated 61 items. Next, let's try to get some summary statistics and visualizations from the user ratings count dataframe.

TODO: Use describe() to report the statistics summary of the user enrollments.

In [56]:
```
## WRITE YOUR CODE HERE
ratings_df.describe()
```

Out[56]:

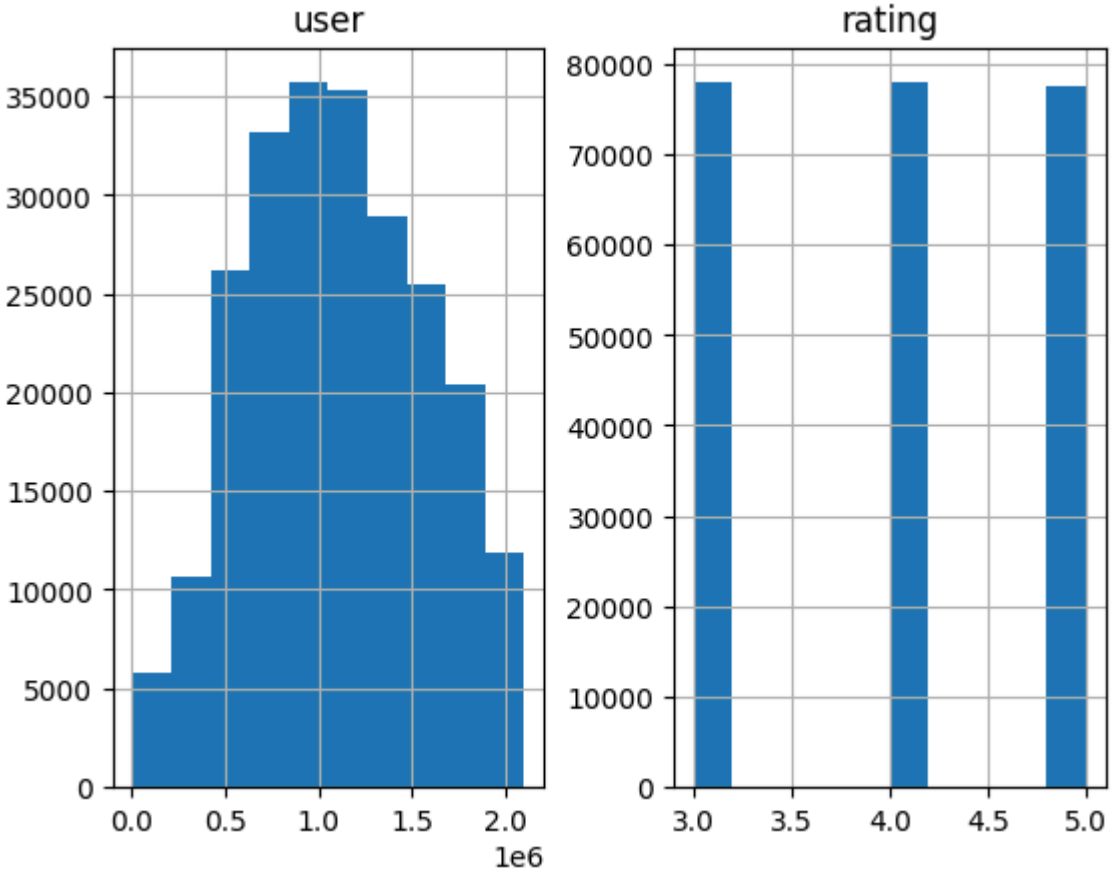
	user	rating
count	2.333060e+05	233306.000000
mean	1.099162e+06	3.998448
std	4.771661e+05	0.816058
min	2.000000e+00	3.000000
25%	7.210400e+05	3.000000
50%	1.080061e+06	4.000000
75%	1.466616e+06	5.000000
max	2.103039e+06	5.000000

We can also get a histogram showing the enrollment distributions, e.g., how many users rated just 1 item or how many rated 10 items, etc.

TODO: Plot the histogram of user rating counts.

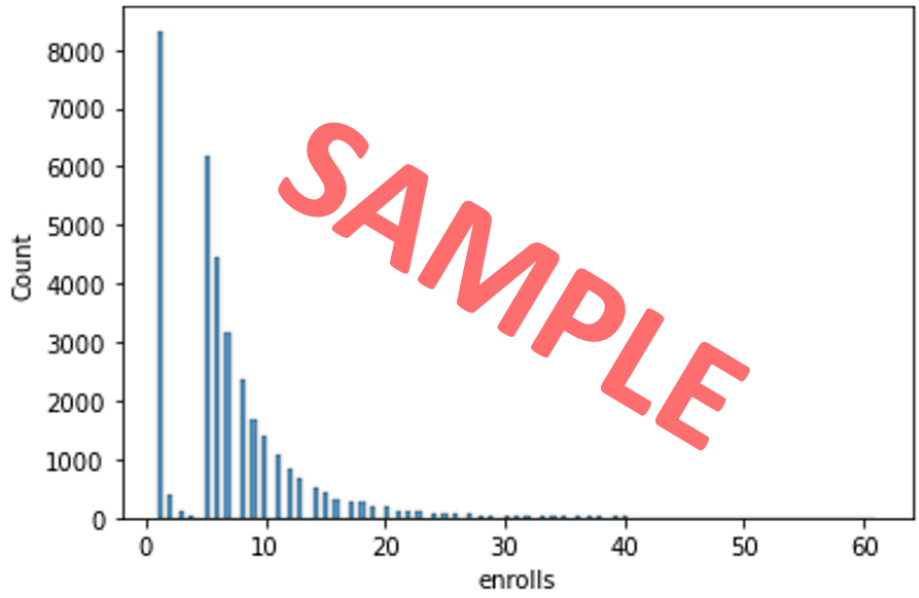
In [57]:
```
# WRITE YOUR CODE HERE
ratings_df.hist()
```

Out[57]:
```
array([[<Axes: title={'center': 'user'}>,
        <Axes: title={'center': 'rating'}>]], dtype=object)
```



▶ Click here for Hints

Your user enrollment histogram may look like the following:



Task: Find the Top-20 Most Popular Courses

Now we know how many items each user rated. Let's see the most popular 20 courses, i.e., items with the most rating counts.

TODO: Use Pandas groupby() and size() methods on the item column to aggregate the rating count for each item, then use the sort_values() method to sort the course enrollment count, and use the slice method to get the top 20 courses. You may also implement this task with different solutions

In [64]:
```
# WRITE YOUR CODE HERE
ratings = ratings_df.groupby(['item']).size().reset_index()
ratings.columns=['course', 'Ratings']
ratings.sort_values(by='Ratings', ascending=False).reset_index(drop=True)
```

Out[64]:

	course	Ratings
0	PY0101EN	14936
1	DS0101EN	14477
2	BD0101EN	13291
3	BD0111EN	10599
4	DA0101EN	8303
...	...	...
121	GPXX0QR3EN	1
122	DX0108EN	1
123	DX0106EN	1
124	ST0301EN	1
125	ST0201EN	1

126 rows × 2 columns

▶ Click here for Hints

Now you may only see the item IDs which do not indicate what kind of courses they are. To make it more clear, we need to join the course titles in the course metadata dataset (`course_df`) so that we can identify what the most popular courses are immediately:

TODO: Use Pandas merge() method to join the course_df (contains the course title column).

In [67]:
```
# WRITE YOUR CODE HERE
merged = pd.merge(ratings,course_df[['COURSE_ID', 'TITLE']],
                  how='left',
                  left_on='course',
                  right_on='COURSE_ID')
merged[['TITLE', 'Ratings']]
```

Out[67]:

	TITLE	Ratings
0	game playing ai with swift for tensorflow s4tf	383
1	blockchain essentials	6719
2	ibm blockchain foundation developer	2866
3	build an iot blockchain network for a supply c...	775
4	big data 101	13291
...	...	...
121	getting started with the data apache spark ma...	347
122	tmp data science bootcamp	35
123	data science bootcamp with python	2
124	watson analytics 101	2247
125	watson analytics for social media	56

126 rows × 2 columns

▶ Click here for Hints

Your most popular 20 courses list may look like the following:

	TITLE	Enrolls
0	python for data science	14936
1	introduction to data science	14477
2	big data 101	13291
3	hadoop 101	10599
4	data analysis with python	8303
5	data science methodology	7719
6	machine learning with python	7644
7	spark fundamentals i	7551
8	data science hands on with open source tools	7199
9	blockchain essentials	6719
10	data visualization with python	6709
11	deep learning 101	6323
12	build your own chatbot	5512
13	r for data science	5237
14	statistics 101	5015
15	introduction to cloud	4983
16	docker essentials a developer introduction	4480
17	sql and relational databases 101	3697
18	mapreduce and yarn	3670
19	data privacy fundamentals	3624

It seems that those popular courses take a huge amount of total ratings. Let's find the exact percentage.

In [68]:
```
# Get the total course enrollments again
total = ratings_df.shape[0]
total
```

Out[68]: 233306

In [69]:
```
top = 0
```

TODO: Get the percentage of the top-20 course enrollments.

In [78]:
```
# WRITE YOUR CODE HERE
top_courses = merged.sort_values(
    by='Ratings',
    ascending=False
).head(20)
top = sum(top_courses['Ratings'].values)
```

▶ Click here for Hints

In [79]:
```
print(f"Percentage of the top course enrollments {round((top * 100)/total, 2)}%"
```

```
Percentage of the top course enrollments 63.3%
```

Summary

Congratulations, you have completed the EDA lab! In this lab, you performed exploratory data analysis on the course metadata and course enrollments datasets and obtained some preliminary understanding.

As you know, these raw datasets can not be used to build recommender systems directly. Later, you will learn and practice how to process them and extract features for machine learning tasks.

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toggle|2021-10-25|1.0|Yan|Created