data_processing

April 23, 2022

1 Data Processing

1.1 Data cleaning

[ ]:
```
import pandas as pd
from fuzzywuzzy import fuzz, process
raw_df = pd.read_excel (r'/Users/swimmingcircle/cs156_code/assignments/
 ↪Final_project/long_form_poll_responses_2019.xlsx')
```

```
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/fuzzywuzzy/fuzz.py:11: UserWarning: Using slow pure-python
SequenceMatcher. Install python-Levenshtein to remove this warning
  warnings.warn('Using slow pure-python SequenceMatcher. Install python-
Levenshtein to remove this warning')
```

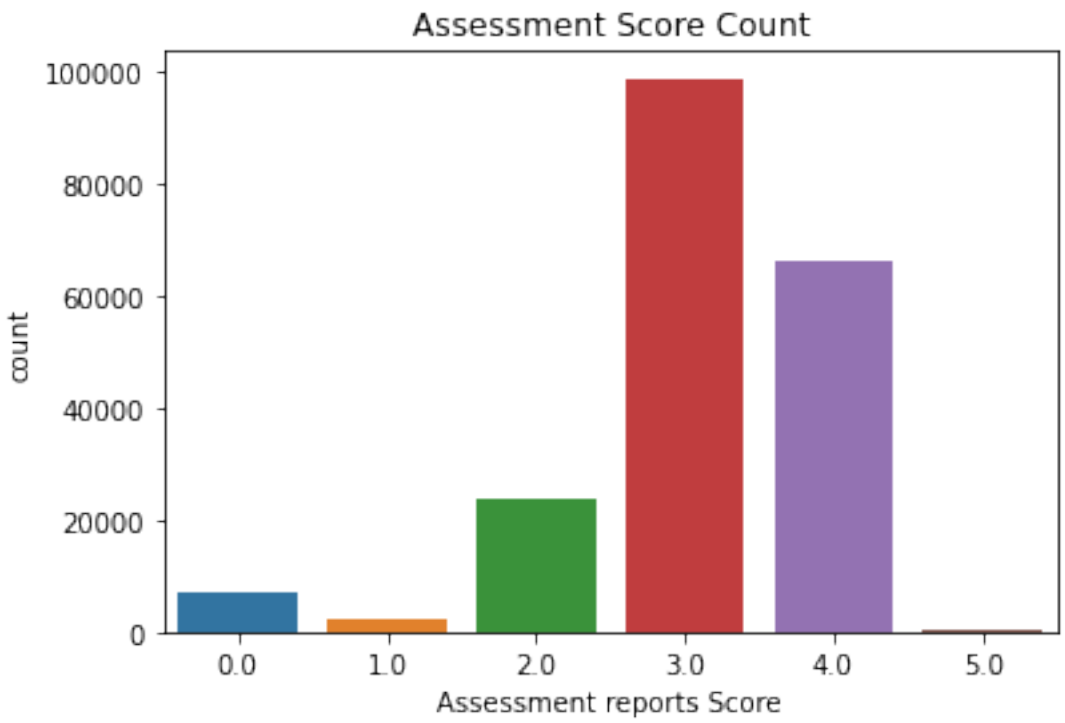
[ ]:
```
#add time stamp as variable
raw_df['time_stamp'] = raw_df['Polls ID'].rank(method = 'dense',␣
 ↪ascending=True).astype(int)
raw_df.sort_values("time_stamp", inplace = True)
```

[ ]:
```
import matplotlib.pyplot as plt
import seaborn as sns
```

[ ]:
```
sns.countplot(raw_df['Assessment reports Score'])
plt.title('Assessment Score Count')
```

```
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/seaborn/_decorators.py:36: FutureWarning: Pass the following variable
as a keyword arg: x. From version 0.12, the only valid positional argument will
be `data`, and passing other arguments without an explicit keyword will result
in an error or misinterpretation.
  warnings.warn(
```

[ ]:
```
Text(0.5, 1.0, 'Assessment Score Count')
```



[ ]:
```
#average
raw_df['Assessment reports Score'].mean()
```

[ ]:
```
3.0913772213247173
```

We can see that most polls are graded as 3, and more polls are graded as 4 than 2. In addition, we see 0 in the grade, which we will need to discard. In addition, the average poll grades is around 3.09.

1.2 Grades for hashtags(HCs & LOs)

[ ]:
```
avg_grades = pd.DataFrame(raw_df.groupby('Assessment reports␣
↪Hashtag')['Assessment reports Score'].agg(['mean', 'count']))
avg_grades = avg_grades.sort_values('mean', ascending= False).reset_index()
```

[ ]:
```
avg_grades
```

[ ]:
```
    Assessment reports Hashtag      mean  count
0         #histonemodifications  4.000000      2
1             #LPimplementation  4.000000      1
2                #networktheory  4.000000      2
3                #Participation  4.000000      3
4                 #Preparedness  4.000000      1
..                          …       …    …
```

```
798              #buckinghampi  2.307692     39
799                        #DA  2.285714     49
800          #Rimplementation  2.178571     28
801           #accountability  1.750000      8
802                       NONE  0.040808   7082

[803 rows x 3 columns]
```

From the result, we can see that some hashtags have a high mean because of few data points. We might discard those hashtags if they bais the result. We will preserve the information for now.

1.3 Discard data

- Discard polls that have NONE for Assessment reports Hashtag
- Discard polls that have't get graded

[ ]:
```
df = raw_df[raw_df['Assessment reports Hashtag'] != 'NONE']
df = raw_df[raw_df['Assessment reports Score'] != 0.0]
```

[ ]:
```
df
```

[ ]:
```
        Polls ID  Assessment reports Student ID  \
0        12522.0                           41.0
16       12522.0                          335.0
15       12522.0                          333.0
14       12522.0                          318.0
13       12522.0                          315.0
…            …                              …
198045  322265.0                         1120.0
198046  322265.0                         1121.0
198047  322265.0                         1126.0
198034  322265.0                          719.0
198079  322265.0                         9357.0

                                  Poll Responses Response  \
0       The strengths of Plato's approach is his const…
16      In the breakout we discussed if outside the ca…
15      I think he's good at reasoning, but he has thi…
14      Back to cmmon confusion time: the section 'und…
13      Most difficult weakness is that his position w…
…                                                     …
198045                                        Definiteness
198046  I think important propoerties of algorithms in…
198047  This is maybe not an additional property, but …
198034  comprehensibility.  This is related to efficie…
198079  Adaptability: I'm not sure if it's actually ap…

       Assessment reports Hashtag  Assessment reports Score  time_stamp
```

```
0                #objectivemorality                    2.0           1
16               #objectivemorality                    3.0           1
15                    #deductivearg                    2.0           1
14               #objectivemorality                    2.0           1
13               #objectivemorality                    2.0           1
…                              …                       …         …
198045     #algorithmicstrategies                      1.0       15539
198046     #algorithmicstrategies                      3.0       15539
198047     #algorithmicstrategies                      3.0       15539
198034     #algorithmicstrategies                      3.0       15539
198079     #algorithmicstrategies                      3.0       15539

[191016 rows x 6 columns]
```

1.4 Text processing

[ ]:
```
import numpy as np
import pandas as pd
import nltk
from nltk.stem.snowball import SnowballStemmer
import re
import os
import codecs
from sklearn import feature_extraction
from nltk.tokenize import RegexpTokenizer
```

[ ]:
```
# load nltk's English stopwords as variable called 'stopwords'
# use nltk.download() to install the corpus first
# Stop Words are words which do not contain important significance to be used␣
 ↪in Search Queries
stopwords = nltk.corpus.stopwords.words('english')

# load nltk's SnowballStemmer as variabled 'stemmer'
stemmer = SnowballStemmer("english")
```

[ ]:
```
df['Poll Responses Response'] = df['Poll Responses Response'].apply(str)

#remove numbers
df['Poll Responses Response'] = df['Poll Responses Response'].str.
 ↪replace(r'\d+','')
```

```
/var/folders/0h/xyv81g2n7sj6zr0c9cw30gkc0000gn/T/ipykernel_17825/2124817980.py:1
: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

```
  df['Poll Responses Response'] = df['Poll Responses Response'].apply(str)
/var/folders/0h/xyv81g2n7sj6zr0c9cw30gkc0000gn/T/ipykernel_17825/2124817980.py:4
: FutureWarning: The default value of regex will change from True to False in a
future version.
  df['Poll Responses Response'] = df['Poll Responses
Response'].str.replace(r'\d+','')
/var/folders/0h/xyv81g2n7sj6zr0c9cw30gkc0000gn/T/ipykernel_17825/2124817980.py:4
: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Poll Responses Response'] = df['Poll Responses
Response'].str.replace(r'\d+','')
```

2 Tokenize and Stem

We tokenize the stem the texts in the poll responses. - Tokenize: Split a sentence into words. We use `RegexpTokenizer` to take out all the punctuations. - Stem: Reduce inflection in words to their root forms. For instance, playing, played, plays will all be presented as play. - Lemmatize: Consider the context and converts the word to its meaningful base form, which is called Lemma. The same word can have multiple different Lemmas. If you lemmatize the word 'Stripes' in verb context, it would return 'Strip'. If you lemmatize it in noun context, it would return 'Stripe'. If you just stem it, it would just return 'Strip'.

We decide to use tokenize and stem as our first step to start. We then take out the stopwords, such as our, ours, same, so, than...

[ ]:
```
tokenizer = RegexpTokenizer("[\w']+")
df['tokenized_responses'] = df['Poll Responses Response'].map(tokenizer.
 ↪tokenize)
df['stemmed_responses'] = df['tokenized_responses'].apply(lambda x: [stemmer.
 ↪stem(y) for y in x])
```

```
/var/folders/0h/xyv81g2n7sj6zr0c9cw30gkc0000gn/T/ipykernel_17825/646613428.py:2:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['tokenized_responses'] = df['Poll Responses
Response'].map(tokenizer.tokenize)
/var/folders/0h/xyv81g2n7sj6zr0c9cw30gkc0000gn/T/ipykernel_17825/646613428.py:3:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead
```

```
See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['stemmed_responses'] = df['tokenized_responses'].apply(lambda x:
[stemmer.stem(y) for y in x])
```

[ ]:
```
df.head()
```

[ ]:
```
    Polls ID  Assessment reports Student ID  \
0    12522.0                          41.0
16   12522.0                         335.0
15   12522.0                         333.0
14   12522.0                         318.0
13   12522.0                         315.0

                             Poll Responses Response  \
0   The strengths of Plato's approach is his const…
16  In the breakout we discussed if outside the ca…
15  I think he's good at reasoning, but he has thi…
14  Back to cmmon confusion time: the section 'und…
13  Most difficult weakness is that his position w…

   Assessment reports Hashtag  Assessment reports Score  time_stamp  \
0          #objectivemorality                       2.0           1
16         #objectivemorality                       3.0           1
15              #deductivearg                       2.0           1
14         #objectivemorality                       2.0           1
13         #objectivemorality                       2.0           1

                                tokenized_responses  \
0   [The, strengths, of, Plato's, approach, is, hi…
16  [In, the, breakout, we, discussed, if, outside…
15  [I, think, he's, good, at, reasoning, but, he,…
14  [Back, to, cmmon, confusion, time, the, sectio…
13  [Most, difficult, weakness, is, that, his, pos…

                                   stemmed_responses
0   [the, strength, of, plato, approach, is, his, …
16  [in, the, breakout, we, discuss, if, outsid, t…
15  [i, think, he, good, at, reason, but, he, has,…
14  [back, to, cmmon, confus, time, the, section, …
13  [most, difficult, weak, is, that, his, posit, …
```

[ ]:
```
#take out stop words
df['clean_responses'] = df['stemmed_responses'].apply(lambda x: [item for item␣
 ↪in x if item not in stopwords])
df['string'] = df['clean_responses'].apply(" ".join)
```

```
/var/folders/0h/xyv81g2n7sj6zr0c9cw30gkc0000gn/T/ipykernel_17825/3547584793.py:2
: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['clean_responses'] = df['stemmed_responses'].apply(lambda x: [item for item
in x if item not in stopwords])
/var/folders/0h/xyv81g2n7sj6zr0c9cw30gkc0000gn/T/ipykernel_17825/3547584793.py:3
: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['string'] = df['clean_responses'].apply(" ".join)
```

3 Add College & hashtag mapping data

We add two datasets, LOs and HCs sheets to map the HCs and LOs to their college in our dataframe df.

[ ]:
```
#LO sheets
los = pd.read_csv("LOs Master List - LOs.csv")
print(los.shape)
los.head()
```

```
(622, 6)
```

[ ]:

	College	Course	LO (please exclude the hashtag)	Rubric	Description	Last Update
0	Arts & Humanities	NaN	NaN	NaN	NaN	NaN
1	AH	AH110	globalruptures	https://forum.minerva.edu/app/outcome-index/le…	Analyze how economic, social, political, intel…	Dec/2020
2	AH	AH110	globalpast	https://forum.minerva.edu/app/outcome-index/le…	Place a historical phenomenon in global perspe…	NaN
3	AH	AH110	glocalization	https://forum.minerva.edu/app/outcome-index/le…		
4	AH	AH110	historicaldebate	https://forum.minerva.edu/app/outcome-index/le…		

```
3  Analyze the mutually-impacting relationship be…         NaN
4  Analyze the way in which secondary sources on …         NaN
```

[ ]:
```
los = los[los['LO (please exclude the hashtag)'].notnull()]
los['LOs/ HCs'] = np.where(los['LO (please exclude the hashtag)'].str[0] ==␣
 ↪'#', los['LO (please exclude the hashtag)'].apply(str.lower).str[1:],␣
 ↪los['LO (please exclude the hashtag)'].str.lower())
los = los.filter(['College', 'Course', 'LOs/ HCs'], axis = 1)

los.head()
```

[ ]:
```
  College Course               LOs/ HCs
1      AH  AH110         globalruptures
2      AH  AH110             globalpast
3      AH  AH110          glocalization
4      AH  AH110       historicaldebate
5      AH  AH110  historicalperspective
```

[ ]:
```
#HC sheet
hcs = pd.read_csv("HCs.csv")
hcs.head()
```

[ ]:
```
  HC (resources on the Hub) Course      Competency  \
0      #confidenceintervals     FA  Analyzing data
1              #correlation     FA  Analyzing data
2         #descriptivestats     FA  Analyzing data
3            #distributions     FA  Analyzing data
4              #probability     FA  Analyzing data

   Brief description (own words)  Priority level for PRODUCT  Plans for use  \
0                            NaN                         NaN            NaN
1                            NaN                         NaN            NaN
2                            NaN                         NaN            NaN
3                            NaN                         NaN            NaN
4                            NaN                         NaN            NaN

   Updates on actual usage  Evidence of strong applications  Other notes
0                      NaN                              NaN          NaN
1                      NaN                              NaN          NaN
2                      NaN                              NaN          NaN
3                      NaN                              NaN          NaN
4                      NaN                              NaN          NaN
```

[ ]:
```
hcs["College"] = hcs["Course"].map({"FA": "CS", "EA": "NS", "MC": "AH", "CX":␣
 ↪"SS"})
hcs["LOs/ HCs"] = hcs["HC (resources on the Hub)"].apply(str.lower).str[2:]
```

```
hcs = hcs.filter(["LOs/ HCs", "College"])
hcs.head()
```

[ ]:

	LOs/ HCs	College
0	confidenceintervals	CS
1	correlation	CS
2	descriptivestats	CS
3	distributions	CS
4	probability	CS

[ ]:
```
#concat LOs and HCs
hcs_and_los = pd.concat([hcs, los], axis = 0)
print(hcs_and_los.shape)
print(len(hcs_and_los["LOs/ HCs"].unique()))

#drop duplicates, because some classes have same LOs
hcs_and_los = hcs_and_los.drop_duplicates(subset='LOs/ HCs', keep='last')
print(hcs_and_los.shape)
```

```
(695, 3)
632
(632, 3)
```

[ ]:
```
df['LOs/ HCs'] = np.where(df['Assessment reports Hashtag'].str[0] == '#',␣
 ↪df['Assessment reports Hashtag'].apply(str.lower).str[1:], df['Assessment␣
 ↪reports Hashtag'].str.lower())
df = df[df["string"].notnull()]
df.head()
```

```
/var/folders/0h/xyv81g2n7sj6zr0c9cw30gkc0000gn/T/ipykernel_17825/4189087042.py:1
: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['LOs/ HCs'] = np.where(df['Assessment reports Hashtag'].str[0] == '#',
df['Assessment reports Hashtag'].apply(str.lower).str[1:], df['Assessment
reports Hashtag'].str.lower())
```

[ ]:

	Polls ID	Assessment reports Student ID	\
0	12522.0	41.0	
16	12522.0	335.0	
15	12522.0	333.0	
14	12522.0	318.0	
13	12522.0	315.0	

	Poll Responses Response	\

```
0   The strengths of Plato's approach is his const…
16  In the breakout we discussed if outside the ca…
15  I think he's good at reasoning, but he has thi…
14  Back to cmmon confusion time: the section 'und…
13  Most difficult weakness is that his position w…

   Assessment reports Hashtag  Assessment reports Score  time_stamp  \
0          #objectivemorality                       2.0           1
16         #objectivemorality                       3.0           1
15              #deductivearg                       2.0           1
14         #objectivemorality                       2.0           1
13         #objectivemorality                       2.0           1

                                tokenized_responses  \
0   [The, strengths, of, Plato's, approach, is, hi…
16  [In, the, breakout, we, discussed, if, outside…
15  [I, think, he's, good, at, reasoning, but, he,…
14  [Back, to, cmmon, confusion, time, the, sectio…
13  [Most, difficult, weakness, is, that, his, pos…

                                  stemmed_responses  \
0   [the, strength, of, plato, approach, is, his, …
16  [in, the, breakout, we, discuss, if, outsid, t…
15  [i, think, he, good, at, reason, but, he, has,…
14  [back, to, cmmon, confus, time, the, section, …
13  [most, difficult, weak, is, that, his, posit, …

                                   clean_responses  \
0   [strength, plato, approach, construct, whole, …
16  [breakout, discuss, outsid, cave, might, bigge…
15  [think, good, reason, circular, way, prove, po…
14  [back, cmmon, confus, time, section, understan…
13  [difficult, weak, posit, understand, testabl, …

                                               string           LOs/ HCs
0   strength plato approach construct whole framew…  objectivemorality
16  breakout discuss outsid cave might bigger cave…  objectivemorality
15  think good reason circular way prove point onl…       deductivearg
14  back cmmon confus time section understand inte…  objectivemorality
13  difficult weak posit understand testabl like i…  objectivemorality
```

[ ]:
```
outer_df = pd.merge(df, hcs_and_los, on='LOs/ HCs', how='outer')

print(outer_df.shape)
outer_df.head()
```

```
(191128, 13)
```

[ ]:

	Polls ID	Assessment reports Student ID	\
0	12522.0	41.0	
1	12522.0	335.0	
2	12522.0	318.0	
3	12522.0	315.0	
4	12522.0	297.0	

	Poll Responses Response	\
0	The strengths of Plato's approach is his const…	
1	In the breakout we discussed if outside the ca…	
2	Back to cmmon confusion time: the section 'und…	
3	Most difficult weakness is that his position w…	
4	I'm still trying to understand the significanc…	

	Assessment reports Hashtag	Assessment reports Score	time_stamp	\
0	#objectivemorality	2.0	1.0	
1	#objectivemorality	3.0	1.0	
2	#objectivemorality	2.0	1.0	
3	#objectivemorality	2.0	1.0	
4	#objectivemorality	2.0	1.0	

	tokenized_responses	\
0	[The, strengths, of, Plato's, approach, is, hi…	
1	[In, the, breakout, we, discussed, if, outside…	
2	[Back, to, cmmon, confusion, time, the, sectio…	
3	[Most, difficult, weakness, is, that, his, pos…	
4	[I'm, still, trying, to, understand, the, sign…	

	stemmed_responses	\
0	[the, strength, of, plato, approach, is, his, …	
1	[in, the, breakout, we, discuss, if, outsid, t…	
2	[back, to, cmmon, confus, time, the, section, …	
3	[most, difficult, weak, is, that, his, posit, …	
4	[i'm, still, tri, to, understand, the, signifi…	

	clean_responses	\
0	[strength, plato, approach, construct, whole, …	
1	[breakout, discuss, outsid, cave, might, bigge…	
2	[back, cmmon, confus, time, section, understan…	
3	[difficult, weak, posit, understand, testabl, …	
4	[i'm, still, tri, understand, signific, cave, …	

	string	LOs/ HCs	\
0	strength plato approach construct whole framew…	objectivemorality	
1	breakout discuss outsid cave might bigger cave…	objectivemorality	
2	back cmmon confus time section understand inte…	objectivemorality	
3	difficult weak posit understand testabl like i…	objectivemorality	

```
4  i'm still tri understand signific cave analog …  objectivemorality

  College Course
0     NaN    NaN
1     NaN    NaN
2     NaN    NaN
3     NaN    NaN
4     NaN    NaN
```

[ ]:
```
#in original dataset
unmatched = outer_df[outer_df["College"].isna()]["LOs/ HCs"].unique()
print(sorted(unmatched)[:10])
print(len(unmatched))
```

```
[' theoreticallevelsofanalysis', 'accountability', 'accountingrules',
'agentsanddevelopment', 'aidtrade', 'alftools', 'algorithmicstrategies',
'analyticalenterprise', 'approxandscaling', 'artcommtheory']
279
```

[ ]:
```
from fuzzywuzzy import process

for lo in unmatched:
    best_match = process.extractOne(lo, hcs_and_los["LOs/ HCs"])
    if best_match[1] <= 70:
        continue
    df.loc[df['LOs/ HCs'] == lo, 'LOs/ HCs'] = best_match[0]

df = df.merge(hcs_and_los, on='LOs/ HCs', how='inner')
df
```

[ ]:
```
        Polls ID  Assessment reports Student ID  \
0        12522.0                           41.0
1        12522.0                          335.0
2        12522.0                          318.0
3        12522.0                          315.0
4        12522.0                          297.0
…            …                              …
181936  320721.0                          301.0
181937  320721.0                           30.0
181938  320721.0                          236.0
181939  320721.0                          247.0
181940  321089.0                           30.0

                                 Poll Responses Response  \
0       The strengths of Plato's approach is his const…
1       In the breakout we discussed if outside the ca…
2       Back to cmmon confusion time: the section 'und…
3       Most difficult weakness is that his position w…
```

```
4       I'm still trying to understand the significanc…
…                                                     …
181936  Emailed it to you earlier. The explanation in …
181937  https://docs.google.com/document/d/JUbBIZWdCAW…
181938  https://docs.google.com/document/d/LBhIrfvdqPf…
181939  . The free energy is F=-NkT*ln(*cosh(dj*beta*<…
181940  I had seen some of these concepts before, but …

       Assessment reports Hashtag  Assessment reports Score  time_stamp  \
0               #objectivemorality                       2.0           1
1               #objectivemorality                       3.0           1
2               #objectivemorality                       2.0           1
3               #objectivemorality                       2.0           1
4               #objectivemorality                       2.0           1
…                              …                         …         …
181936                #IsingModel                        4.0       15312
181937                #IsingModel                        4.0       15312
181938                #IsingModel                        4.0       15312
181939                #IsingModel                        4.0       15312
181940                #IsingModel                        4.0       15334

                                       tokenized_responses  \
0       [The, strengths, of, Plato's, approach, is, hi…
1       [In, the, breakout, we, discussed, if, outside…
2       [Back, to, cmmon, confusion, time, the, sectio…
3       [Most, difficult, weakness, is, that, his, pos…
4       [I'm, still, trying, to, understand, the, sign…
…                                                     …
181936  [Emailed, it, to, you, earlier, The, explanati…
181937  [https, docs, google, com, document, d, JUbBIZ…
181938  [https, docs, google, com, document, d, LBhIrf…
181939  [The, free, energy, is, F, NkT, ln, cosh, dj, …
181940  [I, had, seen, some, of, these, concepts, befo…

                                         stemmed_responses  \
0       [the, strength, of, plato, approach, is, his, …
1       [in, the, breakout, we, discuss, if, outsid, t…
2       [back, to, cmmon, confus, time, the, section, …
3       [most, difficult, weak, is, that, his, posit, …
4       [i'm, still, tri, to, understand, the, signifi…
…                                                     …
181936  [email, it, to, you, earlier, the, explan, in,…
181937  [https, doc, googl, com, document, d, jubbizwd…
181938  [https, doc, googl, com, document, d, lbhirfvd…
181939  [the, free, energi, is, f, nkt, ln, cosh, dj, …
181940  [i, had, seen, some, of, these, concept, befor…
```

```
                                          clean_responses  \
0       [strength, plato, approach, construct, whole, …
1       [breakout, discuss, outsid, cave, might, bigge…
2       [back, cmmon, confus, time, section, understan…
3       [difficult, weak, posit, understand, testabl, …
4       [i'm, still, tri, understand, signific, cave, …
…                                                     …
181936  [email, earlier, explan, cosh, express, larger…
181937  [https, doc, googl, com, document, jubbizwdcaw…
181938  [https, doc, googl, com, document, lbhirfvdqpf…
181939  [free, energi, f, nkt, ln, cosh, dj, beta, h, …
181940  [seen, concept, befor, complet, rigor, grasp, …

                                                   string     LOs/ HCs  \
0       strength plato approach construct whole framew…  objmorality
1       breakout discuss outsid cave might bigger cave…  objmorality
2       back cmmon confus time section understand inte…  objmorality
3       difficult weak posit understand testabl like i…  objmorality
4       i'm still tri understand signific cave analog …  objmorality
…                                                     …          …
181936  email earlier explan cosh express larger one t…   isingmodel
181937  https doc googl com document jubbizwdcawhf_tnv…   isingmodel
181938  https doc googl com document lbhirfvdqpfci khu…   isingmodel
181939  free energi f nkt ln cosh dj beta h thus unmag…   isingmodel
181940  seen concept befor complet rigor grasp though …   isingmodel

       College Course
0           AH  AH111
1           AH  AH111
2           AH  AH111
3           AH  AH111
4           AH  AH111
…          …    …
181936      NS  NS162
181937      NS  NS162
181938      NS  NS162
181939      NS  NS162
181940      NS  NS162

[181941 rows x 13 columns]
```

[ ]:
```
#Check the result
df[df["College"].isna()]
```

[ ]:
```
Empty DataFrame
Columns: [Polls ID, Assessment reports Student ID, Poll Responses Response,
Assessment reports Hashtag, Assessment reports Score, time_stamp,
```

```
tokenized_responses, stemmed_responses, clean_responses, string, LOs/ HCs,
College, Course]
Index: []
```

[ ]:
```
#covert into a csv
compression_opts = dict(method='zip',
                        archive_name='out.csv')
df.to_csv('processed_response.zip', index=False,
          compression=compression_opts)
```

Viz_K-means

April 23, 2022

1 Data Exploration & K-means

[ ]:
```
import numpy as np
import pandas as pd
import sklearn
import seaborn as sns
import matplotlib.pyplot as plt
import random

random.seed(10)
```

[ ]:
```
df = pd.read_csv('processed_response.zip')
```

[ ]:
```
df.head()
```

[ ]:
```
   Polls ID  Assessment reports Student ID  \
0   12522.0                           41.0
1   12522.0                          335.0
2   12522.0                          318.0
3   12522.0                          315.0
4   12522.0                          297.0

                            Poll Responses Response  \
0  The strengths of Plato's approach is his const…
1  In the breakout we discussed if outside the ca…
2  Back to cmmon confusion time: the section 'und…
3  Most difficult weakness is that his position w…
4  I'm still trying to understand the significanc…

  Assessment reports Hashtag  Assessment reports Score  time_stamp  \
0         #objectivemorality                        2.0           1
1         #objectivemorality                        3.0           1
2         #objectivemorality                        2.0           1
3         #objectivemorality                        2.0           1
4         #objectivemorality                        2.0           1

                                tokenized_responses  \
```

```
0  ['The', 'strengths', 'of', "Plato's", 'approac…
1  ['In', 'the', 'breakout', 'we', 'discussed', '…
2  ['Back', 'to', 'cmmon', 'confusion', 'time', '…
3  ['Most', 'difficult', 'weakness', 'is', 'that'…
4  ["I'm", 'still', 'trying', 'to', 'understand',…

                                  stemmed_responses  \
0  ['the', 'strength', 'of', 'plato', 'approach',…
1  ['in', 'the', 'breakout', 'we', 'discuss', 'if…
2  ['back', 'to', 'cmmon', 'confus', 'time', 'the…
3  ['most', 'difficult', 'weak', 'is', 'that', 'h…
4  ["i'm", 'still', 'tri', 'to', 'understand', 't…

                                    clean_responses  \
0  ['strength', 'plato', 'approach', 'construct',…
1  ['breakout', 'discuss', 'outsid', 'cave', 'mig…
2  ['back', 'cmmon', 'confus', 'time', 'section',…
3  ['difficult', 'weak', 'posit', 'understand', '…
4  ["i'm", 'still', 'tri', 'understand', 'signifi…

                                              string     LOs/ HCs College  \
0  strength plato approach construct whole framew…  objmorality      AH
1  breakout discuss outsid cave might bigger cave…  objmorality      AH
2  back cmmon confus time section understand inte…  objmorality      AH
3  difficult weak posit understand testabl like i…  objmorality      AH
4  i'm still tri understand signific cave analog …  objmorality      AH

  Course
0  AH111
1  AH111
2  AH111
3  AH111
4  AH111
```

[ ]:
```
df['string'] = df['string'].values.astype('U')
```

2 Transform dataframe into tfidf

Key points - Tf-idf computes weights of the words (how relevant they are in the document) - The higher the TF-IDF score, the rare or unique the term is, and vice versa - TF and IDF are calculated in different ways (either by ranking frequency values, or by dividing the words frequency overall by the number of words given in the dictionary)

Formula

- Term Frequency (TF):
  - Calculate the term frequency
  - tf(t,d) = count of t in d / number of words in d

- Inverse Document Frequency(IDF)
  - Weigh down the frequent terms may appear a lot of times but have little importance
  - idf(t) = log(N/(df + 1))
- Calculation: TF is multiplied by IDF

[ ]:
```
from sklearn.feature_extraction.text import TfidfVectorizer

tfidf_vector = TfidfVectorizer()
tfidf_matrix = tfidf_vector.fit_transform(df['string'])
tfidf_matrix
```

[ ]:
```
<181941x79400 sparse matrix of type '<class 'numpy.float64'>'
        with 6018555 stored elements in Compressed Sparse Row format>
```

[ ]:
```
#Explore td-idf for one doc: print words & tf-idf scores
feature_names = tfidf_vector.get_feature_names()
doc = 3 #random doc
feature_index = tfidf_matrix[doc,:].nonzero()[1] #Return the indices of the␣
 ↪elements that are non-zero.
tfidf_scores = zip(feature_index, [tfidf_matrix[doc, x] for x in feature_index])
for w, s in [(feature_names[i], s) for (i, s) in tfidf_scores]:
  print(w, s)
```

```
get 0.1602432886945829
way 0.14154666427634024
ani 0.18754112365767017
whether 0.1909802791293325
decid 0.22724769256321592
lot 0.1967549100540339
quit 0.2530798913029075
struggl 0.2884601285317333
peopl 0.13840463662592684
incomprehens 0.451983870307689
like 0.13508086186616905
testabl 0.27084504953544314
posit 0.1880356167579713
difficult 0.23321560468563032
understand 0.15017855307918143
cave 0.3964584008260598
weak 0.24596725240200004
```

```
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/sklearn/utils/deprecation.py:87: FutureWarning: Function
get_feature_names is deprecated; get_feature_names is deprecated in 1.0 and will
be removed in 1.2. Please use get_feature_names_out instead.
  warnings.warn(msg, category=FutureWarning)
```

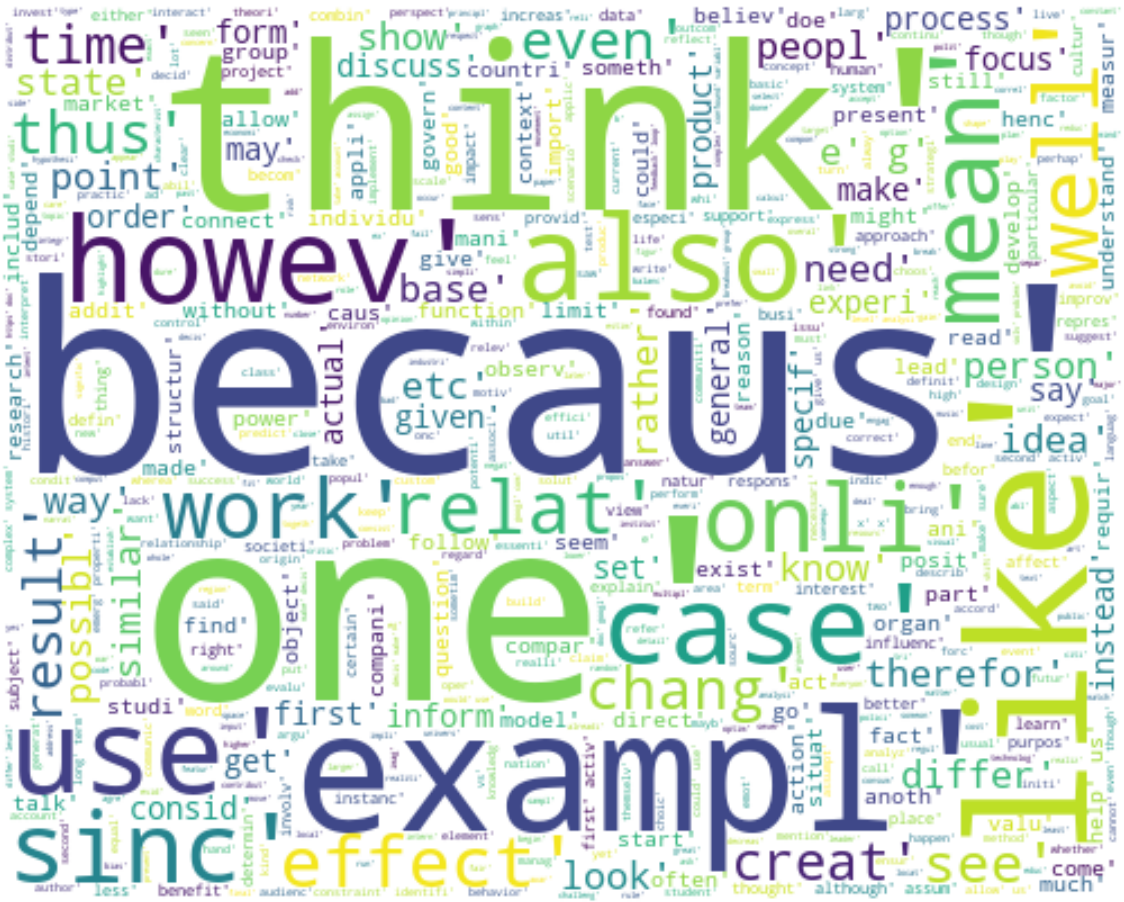
We explore words and their tf-idf scores for a random poll response in our dataset.

3 Visualized by wordcloud

3.1 Visualize bags of words

[ ]:
```
# Import the wordcloud library
from wordcloud import WordCloud

# Join the different processed titles together.
long_string = ','.join(df['clean_responses'])

plt.figure(figsize=(40, 30))
# Create a WordCloud object
wordcloud = WordCloud(width = 500, height = 400, background_color="white",␣
 ↪max_words=5000)
# Generate a word cloud
wordcloud.generate(long_string)
# Visualize the word cloud
wordcloud.to_image()
```

[ ]:




```
<Figure size 2880x2160 with 0 Axes>
```

3.2 Visualize tf-idf

We visualize the word cloud for tf-idf matrix as well, since it takes a long time to run, we slice the matrix that remains around 20% (15000/total # of cols) of the information.

[ ]:
```
tfidf_matrix
```

[ ]:
```
<181941x79400 sparse matrix of type '<class 'numpy.float64'>'
        with 6018555 stored elements in Compressed Sparse Row format>
```

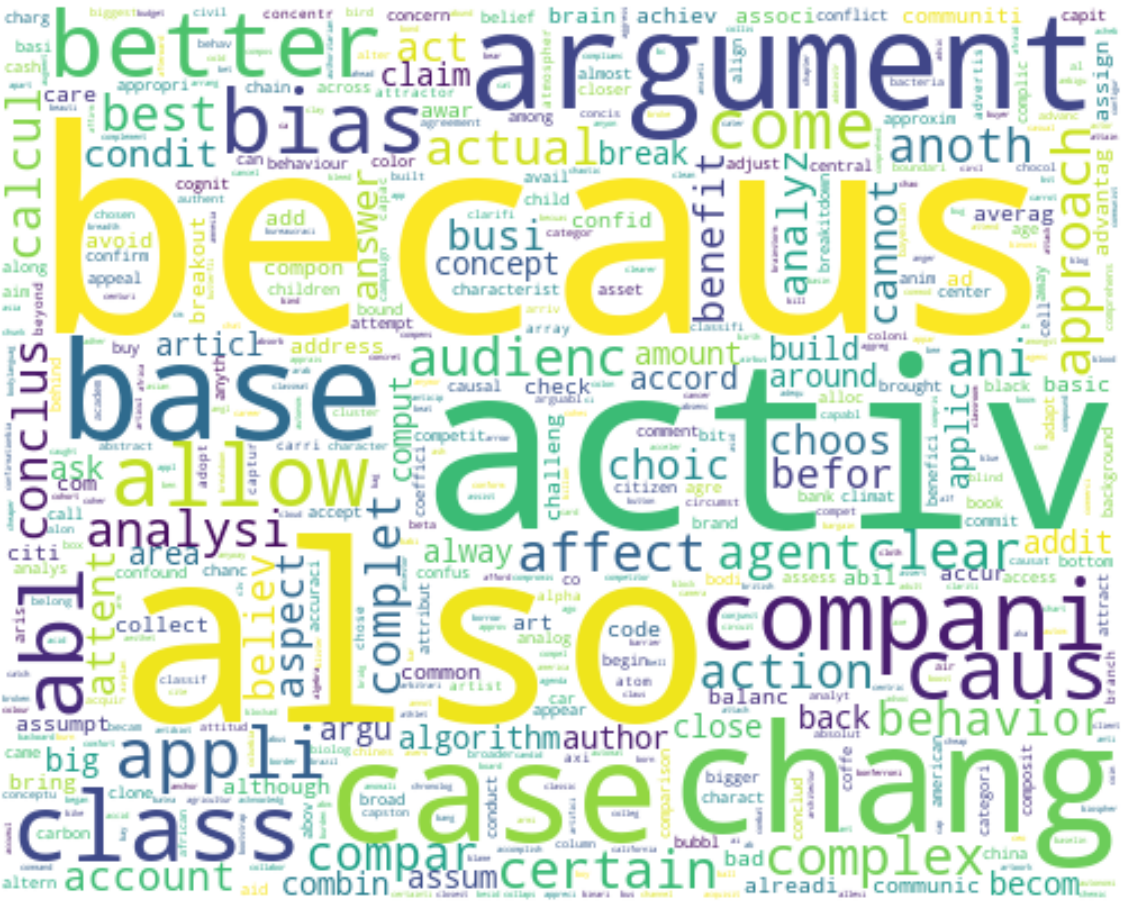
[ ]:
```
response = tfidf_matrix[:, :15000] #slice the matrix
df_tfidf_sklearn = pd.DataFrame(response.toarray(),columns= tfidf_vector.
 ↪get_feature_names()[:15000])
df_tfidf_sklearn.head()
```

[ ]:
```
    __  ___  ____  _____  ______  _______  ________  __________  ___________  \
0  0.0  0.0   0.0    0.0     0.0      0.0       0.0         0.0          0.0
1  0.0  0.0   0.0    0.0     0.0      0.0       0.0         0.0          0.0
2  0.0  0.0   0.0    0.0     0.0      0.0       0.0         0.0          0.0
3  0.0  0.0   0.0    0.0     0.0      0.0       0.0         0.0          0.0
4  0.0  0.0   0.0    0.0     0.0      0.0       0.0         0.0          0.0

   _____________  …  conjunst  conjunt  conjur  conjvey  conlad  conland  \
0            0.0  …       0.0      0.0     0.0      0.0     0.0      0.0
1            0.0  …       0.0      0.0     0.0      0.0     0.0      0.0
2            0.0  …       0.0      0.0     0.0      0.0     0.0      0.0
3            0.0  …       0.0      0.0     0.0      0.0     0.0      0.0
4            0.0  …       0.0      0.0     0.0      0.0     0.0      0.0

   conlcud  conlcus  conley  conlfict
0      0.0      0.0     0.0       0.0
1      0.0      0.0     0.0       0.0
2      0.0      0.0     0.0       0.0
3      0.0      0.0     0.0       0.0
4      0.0      0.0     0.0       0.0

[5 rows x 15000 columns]
```

[ ]:
```
#some up all frequency
tf_idf_counter = df_tfidf_sklearn.T.sum(axis=1)
```

[ ]:
```
wordcloud = WordCloud(width = 500, height = 400, background_color="white",␣
 ↪max_words=5000)
wordcloud.generate_from_frequencies(tf_idf_counter)
wordcloud.to_image()
```

[ ]:



From the word clouds, we layout the common words for bags of words and - Bags of words: think, one, because, also, however, like, example, use, work, only, need, know, mean, relate, use, effect. - Tf-idf: because, also, change, base, case, active, companies, arguement, affect, class, apply,complex, allow, better, bias.

We obseverve that though the most common words for both bags of words and tf-idf only provide us words the appear freuqnently, tf-idf gives us more useful information.

3.3 Cluster by K means

3.3.1 5 clusters

[ ]:
```
from sklearn.cluster import KMeans

num_clusters = 5

km = KMeans(n_clusters=num_clusters)

%time km.fit(tfidf_matrix)
```

```
clusters = km.labels_.tolist()

df['cluster'] = np.array(clusters)
terms = tfidf_vector.get_feature_names_out()
```

```
CPU times: user 4min 4s, sys: 8.96 s, total: 4min 13s
Wall time: 38.2 s
```

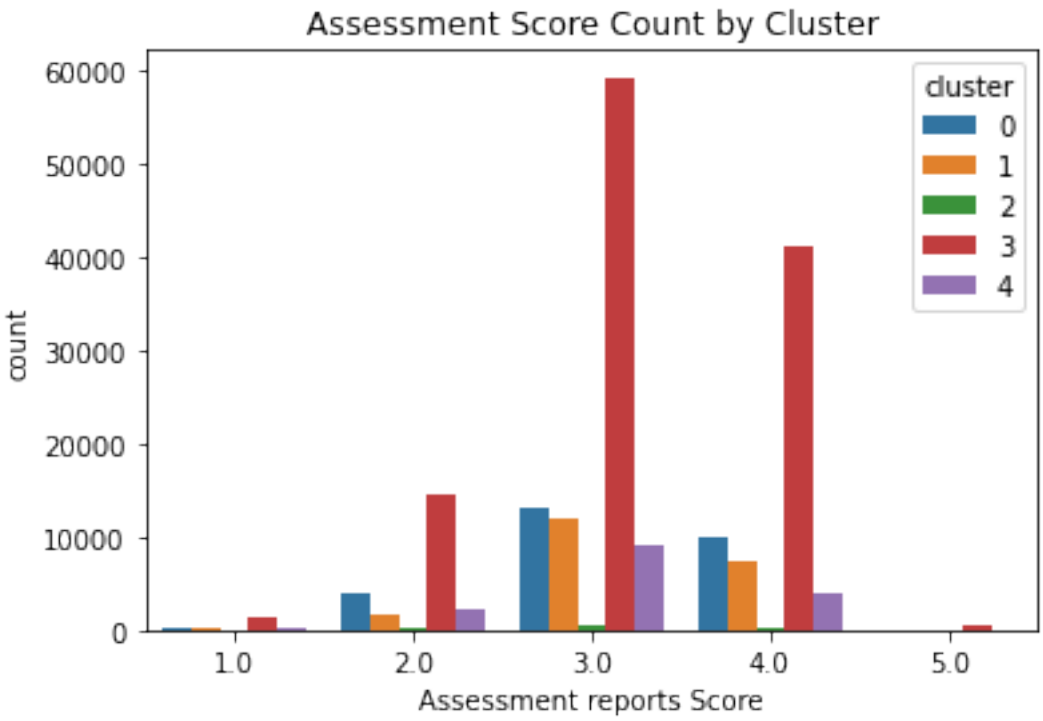
[ ]:
```
print("Top terms per cluster:")
print()
#sort cluster centers by proximity to centroid
order_centroids = km.cluster_centers_.argsort()[:, ::-1] #sort in decending␣
 ↪order

for i in range(num_clusters):
    print("Cluster %d words:" % i, end='')

    for ind in order_centroids[i, :15]: # with 15 words per cluster
        print(' %s' % terms[ind],end=',')
    print() #add whitespace

print()
print()
```

```
Top terms per cluster:

Cluster 0 words: data, variabl, model, use, sampl, would, valu, distribut,
probabl, test, hypothesi, observ, studi, mean, differ,
Cluster 1 words: compani, market, product, custom, risk, busi, com, countri,
https, invest, cost, price, economi, googl, growth,
Cluster 2 words: poll, complet, student, present,
faazillexzvnfbceqmeprnivsrzaadmewqcnu, fabian, fabianokafor, fabiola, fabl,
fabric, fabul, fac, faabi, facad, facbook,
Cluster 3 words: would, use, becaus, one, peopl, think, make, differ, also,
exampl, like, could, argument, way, time,
Cluster 4 words: problem, system, level, solut, emerg, solv, agent, differ,
complex, interact, individu, properti, use, analysi, understand,
```

[ ]:
```
sns.countplot('Assessment reports Score', hue = 'cluster', data = df)
plt.title('Assessment Score Count by Cluster')
```

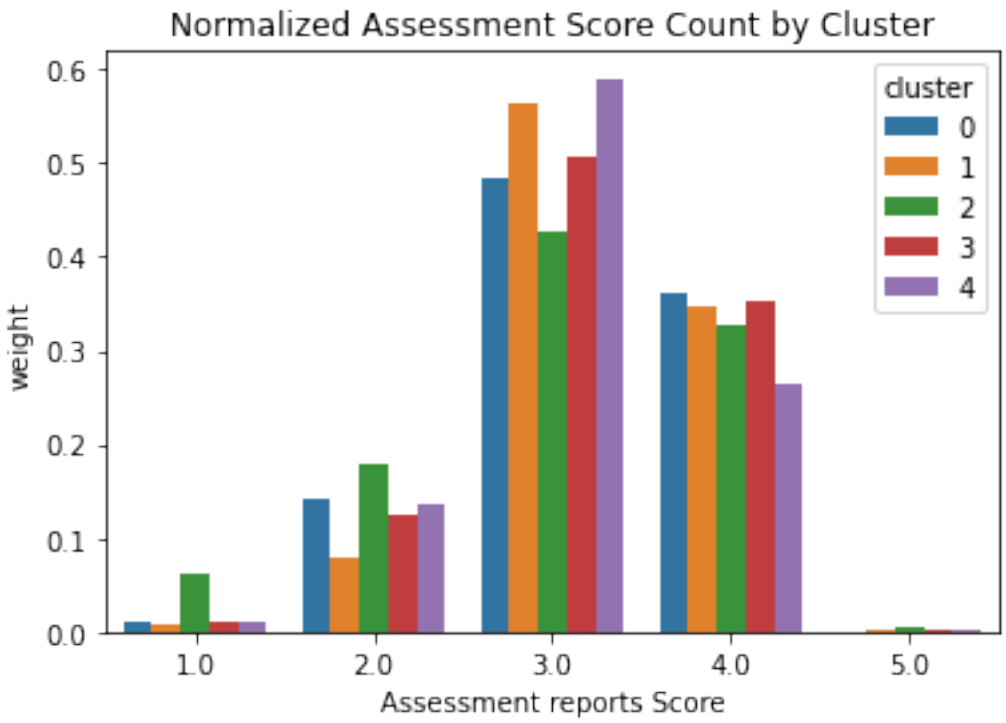
```
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/seaborn/_decorators.py:36: FutureWarning: Pass the following variable
as a keyword arg: x. From version 0.12, the only valid positional argument will
be `data`, and passing other arguments without an explicit keyword will result
in an error or misinterpretation.
  warnings.warn(
```

[ ]: Text(0.5, 1.0, 'Assessment Score Count by Cluster')

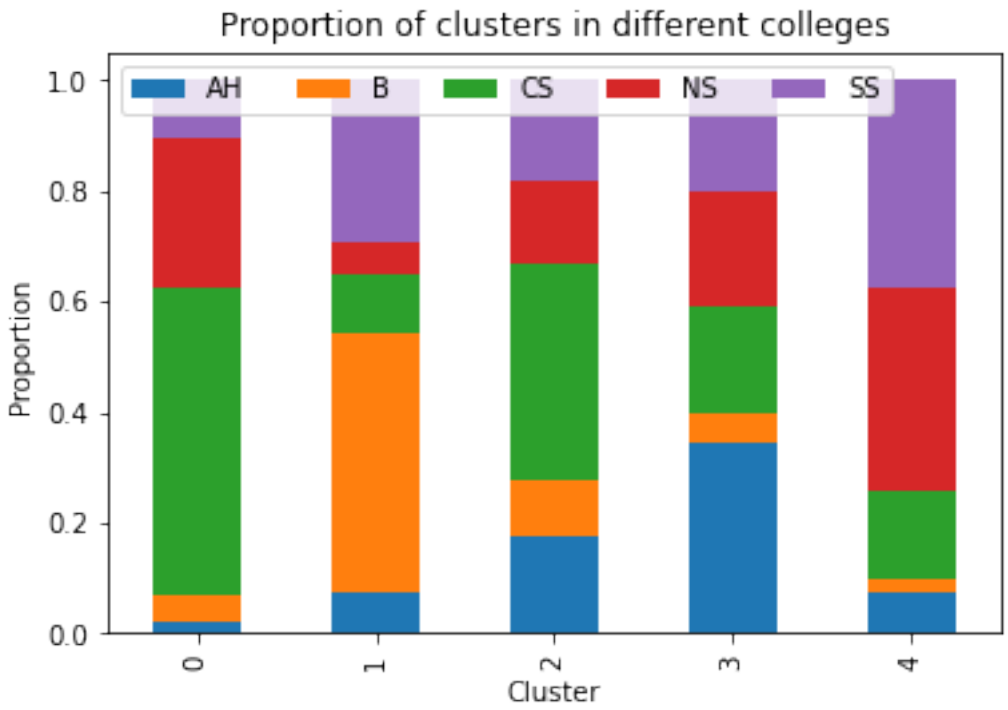


[ ]:
```
# Normalize the score distribution per cluster
norm_df = df["Assessment reports Score"].groupby(df["cluster"]).value_counts().
 ↪rename('count').reset_index()
norm_df = norm_df.assign(weight=norm_df['count']/norm_df.
 ↪groupby('cluster')['count'].transform('sum'))

sns.barplot(x="Assessment reports Score", y="weight", hue = 'cluster',␣
 ↪data=norm_df)
plt.title('Normalized Assessment Score Count by Cluster')
```

[ ]: Text(0.5, 1.0, 'Normalized Assessment Score Count by Cluster')



[ ]:
```
# College distribution per cluster
cross_tab_prop = pd.crosstab(index=df['cluster'],
                             columns=df['College'],
                             normalize="index")
cross_tab_prop


cross_tab_prop.plot(kind='bar',
                    stacked=True)

plt.legend(loc="upper left", ncol = 5)
plt.xlabel("Cluster")
plt.ylabel("Proportion")
plt.title("Proportion of clusters in different colleges")
plt.show()
```



3.3.2 10 clusters

[ ]:
```
km_10 = KMeans(n_clusters=10)

%time km_10.fit(tfidf_matrix)

clusters10 = km_10.labels_.tolist()

df['cluster10'] = np.array(clusters10)
terms10 = tfidf_vector.get_feature_names_out()
```

```
CPU times: user 5min 32s, sys: 11.3 s, total: 5min 44s
Wall time: 52.5 s
```

[ ]:
```
print("Top terms per cluster:")
print()
#sort cluster centers by proximity to centroid
order_centroids = km_10.cluster_centers_.argsort()[:, ::-1]

for i in range(10):
    print("Cluster %d words:" % i, end='')

    for ind in order_centroids[i, :15]: #replace 6 with n words per cluster
        print(' %s' % terms10[ind],end=',')
```

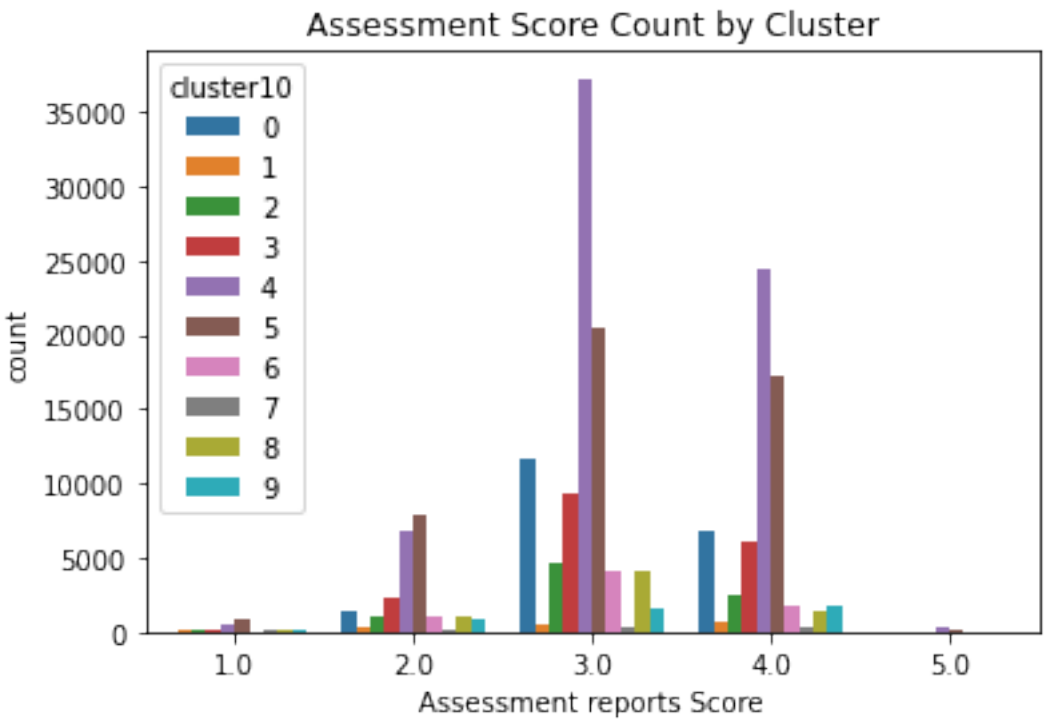
```
    print() #add whitespace

print()
print()
```

```
Top terms per cluster:

Cluster 0 words: compani, market, product, custom, risk, busi, countri, invest,
cost, economi, price, would, growth, financi, increas,
Cluster 1 words: doc, https, com, googl, edit, document, usp, share, kgi, edu,
minerva, spreadsheet, drive, colab, gid,
Cluster 2 words: system, level, emerg, agent, interact, properti, individu,
complex, network, differ, predict, behavior, analysi, understand, social,
Cluster 3 words: data, variabl, model, hypothesi, studi, test, observ, use,
would, differ, predict, control, treatment, regress, one,
Cluster 4 words: peopl, think, use, one, would, becaus, differ, make, way, like,
also, exampl, understand, could, person,
Cluster 5 words: would, time, use, function, valu, becaus, number, one, chang,
node, vector, differ, get, tree, first,
Cluster 6 words: argument, thesi, sentenc, evid, induct, logic, premis, deduct,
conclus, true, statement, use, truth, claim, clone,
Cluster 7 words: poll, complet, student, present,
faazillexzvnfbceqmeprnivsrzaadmewqcnu, fabian, fabianokafor, fabiola, fabl,
fabric, fabul, fac, faabi, facad, facbook,
Cluster 8 words: problem, solut, solv, constraint, use, water, rightproblem,
identifi, differ, state, goal, breakitdown, subproblem, step, one,
Cluster 9 words: distribut, sampl, probabl, normal, mean, interv, score, calcul,
would, use, valu, confid, size, number, trial,
```

[ ]:
```
sns.countplot('Assessment reports Score', hue = 'cluster10', data = df)
plt.title('Assessment Score Count by Cluster')
```

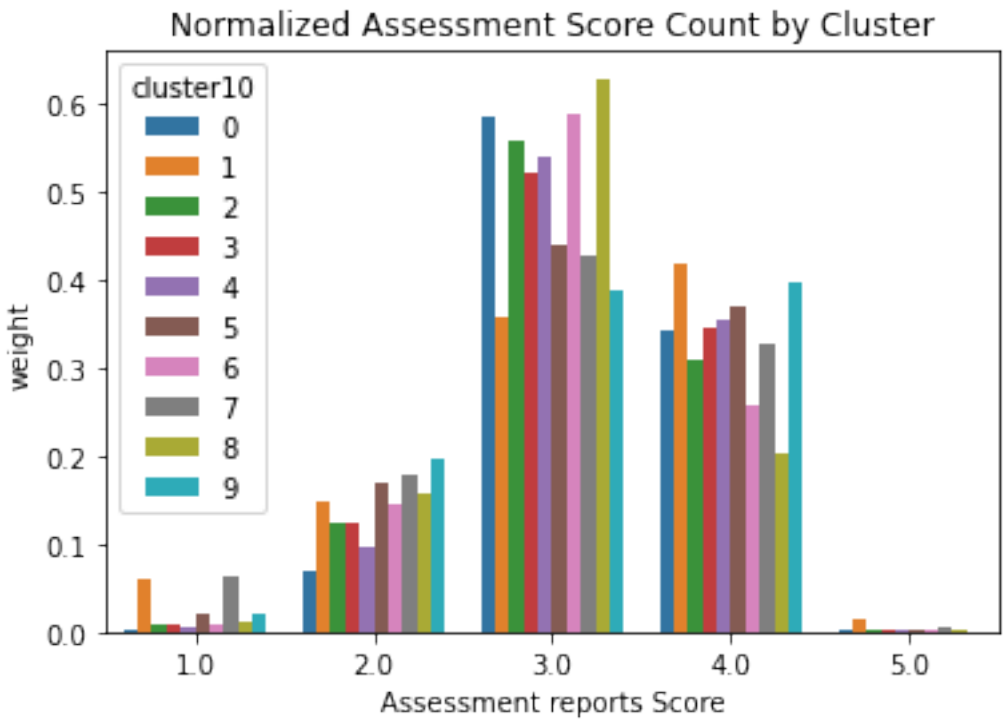
```
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/seaborn/_decorators.py:36: FutureWarning: Pass the following variable
as a keyword arg: x. From version 0.12, the only valid positional argument will
be `data`, and passing other arguments without an explicit keyword will result
in an error or misinterpretation.
  warnings.warn(
```

[ ]:
```
Text(0.5, 1.0, 'Assessment Score Count by Cluster')
```

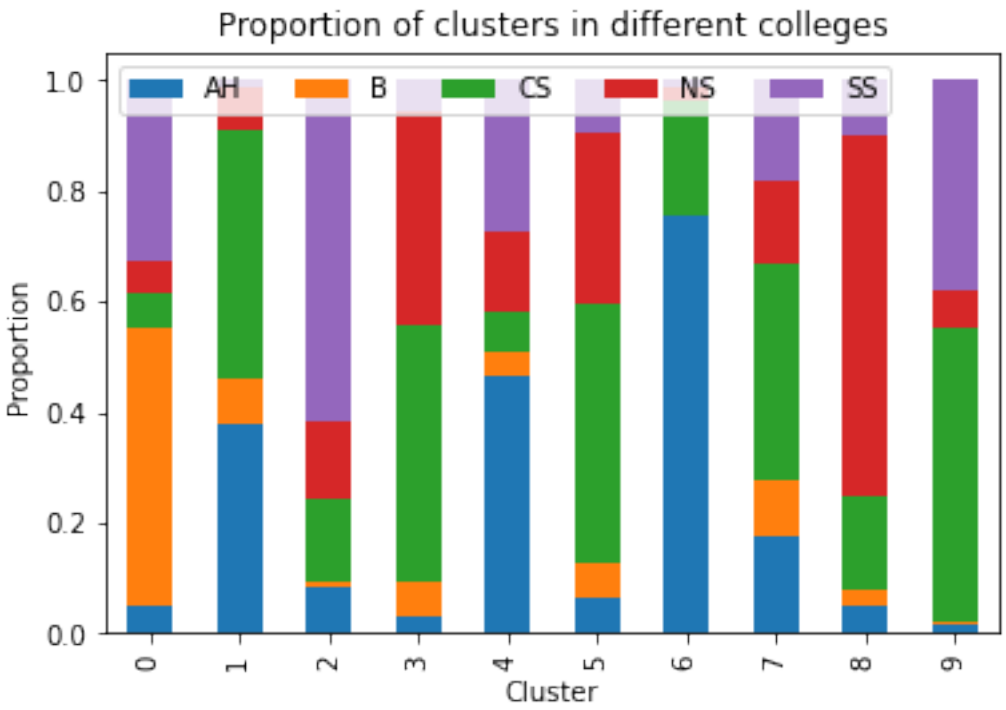


[ ]:
```
norm_df10 = df["Assessment reports Score"].groupby(df["cluster10"]).
 ↪value_counts().rename('count').reset_index()
norm_df10 = norm_df10.assign(weight=norm_df10['count']/norm_df10.
 ↪groupby('cluster10')['count'].transform('sum'))

sns.barplot(x="Assessment reports Score", y="weight", hue = 'cluster10',␣
 ↪data=norm_df10)
plt.title('Normalized Assessment Score Count by Cluster')
```

[ ]:
```
Text(0.5, 1.0, 'Normalized Assessment Score Count by Cluster')
```



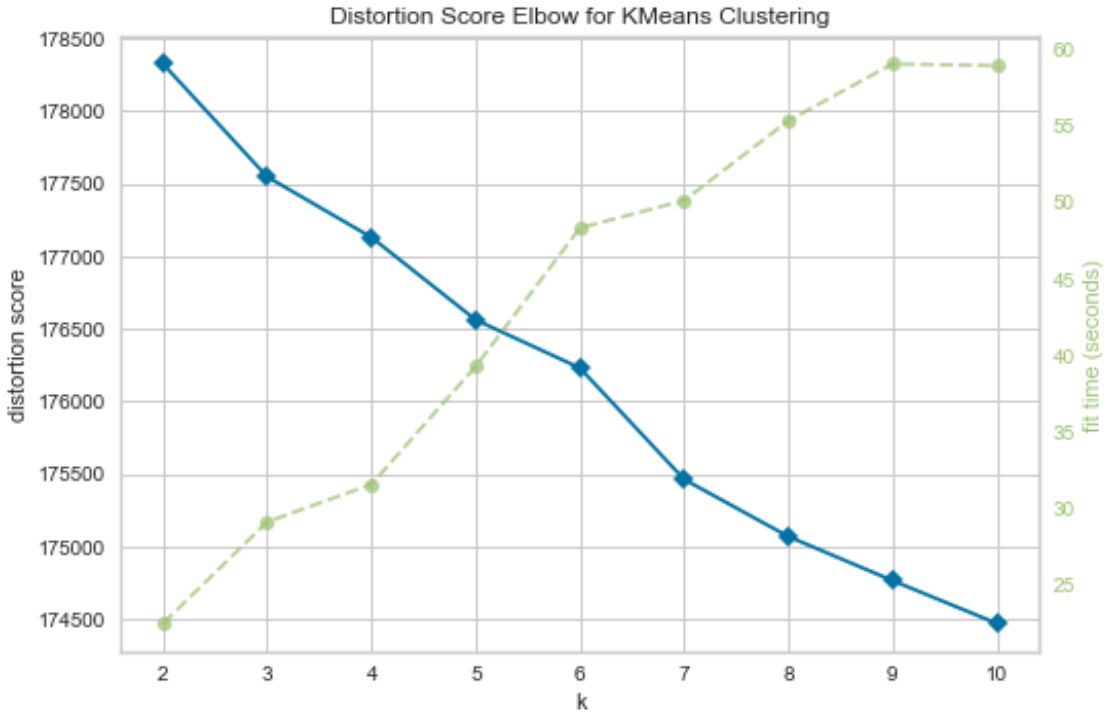
[ ]:
```
cross_tab_prop = pd.crosstab(index=df['cluster10'],
                             columns=df['College'],
                             normalize="index")
cross_tab_prop


cross_tab_prop.plot(kind='bar',
                    stacked=True)

plt.legend(loc="upper left", ncol = 5)
plt.xlabel("Cluster")
plt.ylabel("Proportion")
plt.title("Proportion of clusters in different colleges")
plt.show()
```



4 Select the best number of clusters

[ ]:
```
from yellowbrick.cluster import KElbowVisualizer, SilhouetteVisualizer

visualizer = KElbowVisualizer(km, k=(2,11))

visualizer.fit(tfidf_matrix)
visualizer.show()
```

```
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/sklearn/utils/validation.py:593: FutureWarning: np.matrix usage is
deprecated in 1.0 and will raise a TypeError in 1.2. Please convert to a numpy
array with np.asarray. For more information see:
https://numpy.org/doc/stable/reference/generated/numpy.matrix.html
  warnings.warn(
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/sklearn/utils/validation.py:593: FutureWarning: np.matrix usage is
deprecated in 1.0 and will raise a TypeError in 1.2. Please convert to a numpy
array with np.asarray. For more information see:
https://numpy.org/doc/stable/reference/generated/numpy.matrix.html
  warnings.warn(
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/sklearn/utils/validation.py:593: FutureWarning: np.matrix usage is
```



[ ]:
```
<AxesSubplot:title={'center':'Distortion Score Elbow for KMeans Clustering'},
xlabel='k', ylabel='distortion score'>
```

We cannot see a clear elbow point here, but it seems that 7 is the best number of clusters.

[ ]:
```
km_7 = KMeans(n_clusters=7)

%time km_7.fit(tfidf_matrix)

clusters7 = km_7.labels_.tolist()

df['cluster7'] = np.array(clusters7)
terms10 = tfidf_vector.get_feature_names_out()
```

```
CPU times: user 5min 52s, sys: 12.3 s, total: 6min 5s
Wall time: 54.7 s
```

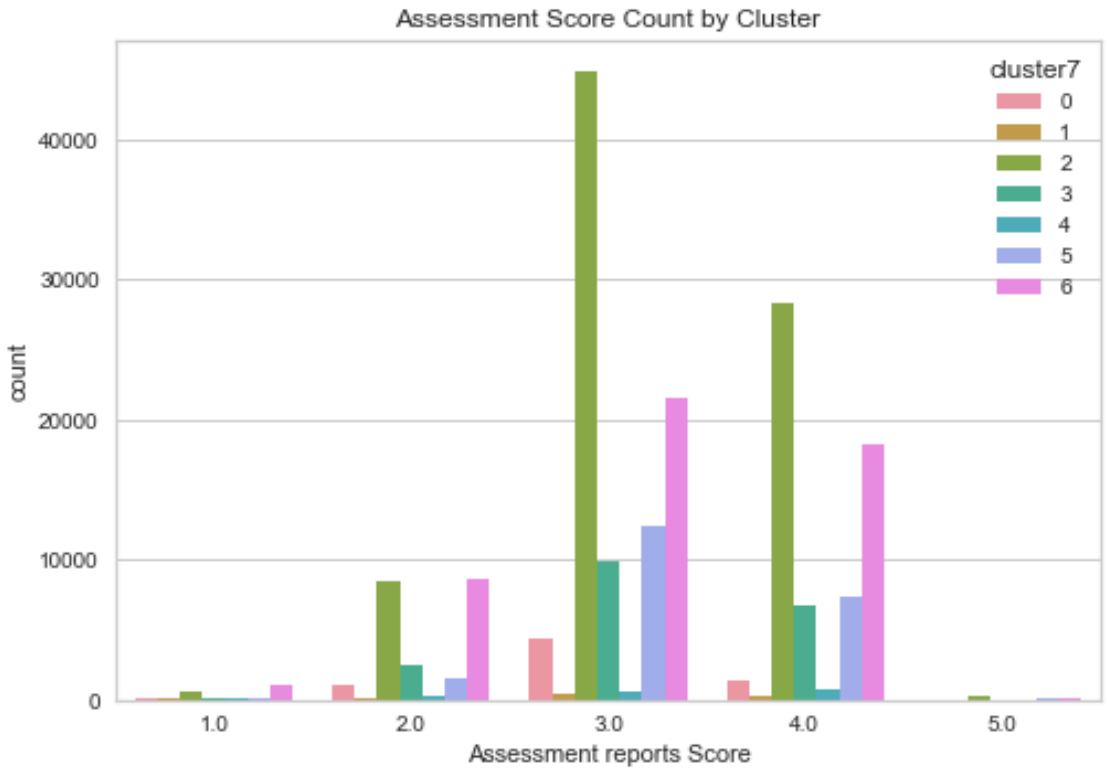
[ ]:
```
print("Top terms per cluster:")
print()
#sort cluster centers by proximity to centroid
order_centroids = km_7.cluster_centers_.argsort()[:, ::-1]

for i in range(7):
    print("Cluster %d words:" % i, end='')
```

```
    for ind in order_centroids[i, :15]: #with 15 words per cluster
        print(' %s' % terms10[ind],end=',')
    print() #add whitespace

print()
print()
```

```
Top terms per cluster:

Cluster 0 words: problem, solut, solv, constraint, water, use, rightproblem,
differ, identifi, state, goal, breakitdown, subproblem, step, one,
Cluster 1 words: poll, complet, student, present,
faazillexzvnfbceqmeprnivsrzaadmewqcnu, fabian, fabianokafor, fabiola, fabl,
fabric, fabul, fac, faabi, facad, facbook,
Cluster 2 words: peopl, use, one, think, would, becaus, differ, make, exampl,
argument, understand, system, also, way, like,
Cluster 3 words: data, variabl, model, hypothesi, studi, observ, use, test,
would, predict, differ, control, treatment, one, regress,
Cluster 4 words: doc, https, com, googl, edit, document, usp, share, kgi, edu,
minerva, spreadsheet, drive, colab, gid,
Cluster 5 words: compani, market, product, custom, risk, countri, busi, economi,
cost, invest, would, price, growth, financi, increas,
Cluster 6 words: would, valu, use, probabl, time, becaus, number, function,
mean, distribut, one, sampl, get, first, node,
```

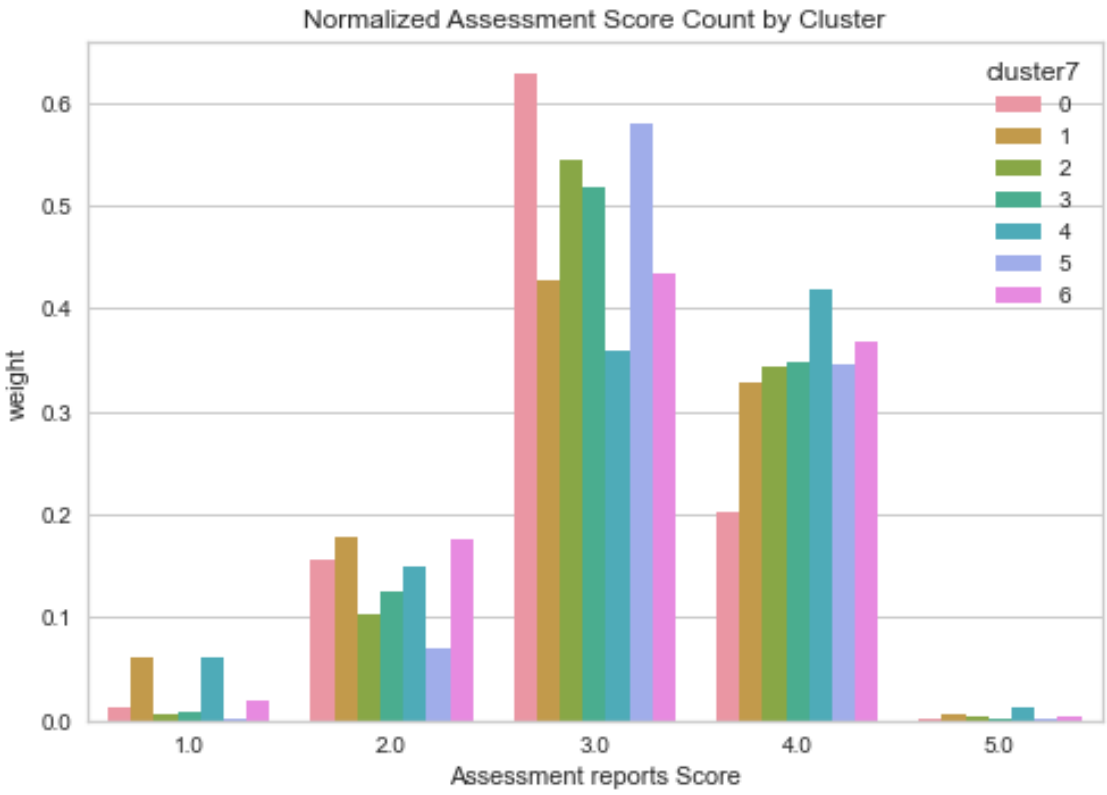
[ ]:
```
sns.countplot('Assessment reports Score', hue = 'cluster7', data = df)
plt.title('Assessment Score Count by Cluster')
```

[ ]:
```
Text(0.5, 1.0, 'Assessment Score Count by Cluster')
```

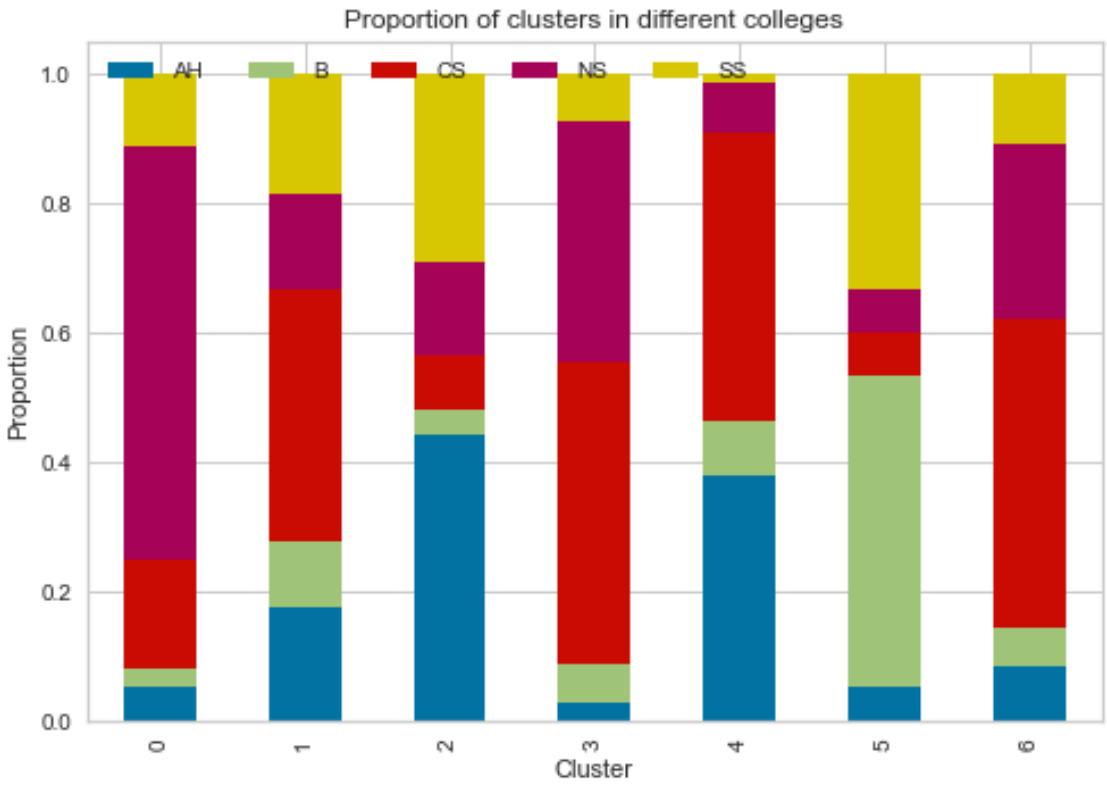


[ ]:
```
norm_df7 = df["Assessment reports Score"].groupby(df["cluster7"]).
 ↪value_counts().rename('count').reset_index()
norm_df7 = norm_df7.assign(weight=norm_df7['count']/norm_df7.
 ↪groupby('cluster7')['count'].transform('sum'))

sns.barplot(x="Assessment reports Score", y="weight", hue = 'cluster7',␣
 ↪data=norm_df7)
plt.title('Normalized Assessment Score Count by Cluster')
```

[ ]:
```
Text(0.5, 1.0, 'Normalized Assessment Score Count by Cluster')
```



[ ]:
```
cross_tab_prop = pd.crosstab(index=df['cluster7'],
                             columns=df['College'],
                             normalize="index")
cross_tab_prop


cross_tab_prop.plot(kind='bar',
                    stacked=True)

plt.legend(loc="upper left", ncol = 5)
plt.xlabel("Cluster")
plt.ylabel("Proportion")
plt.title("Proportion of clusters in different colleges")
plt.show()
```



5 Visualize K-means result

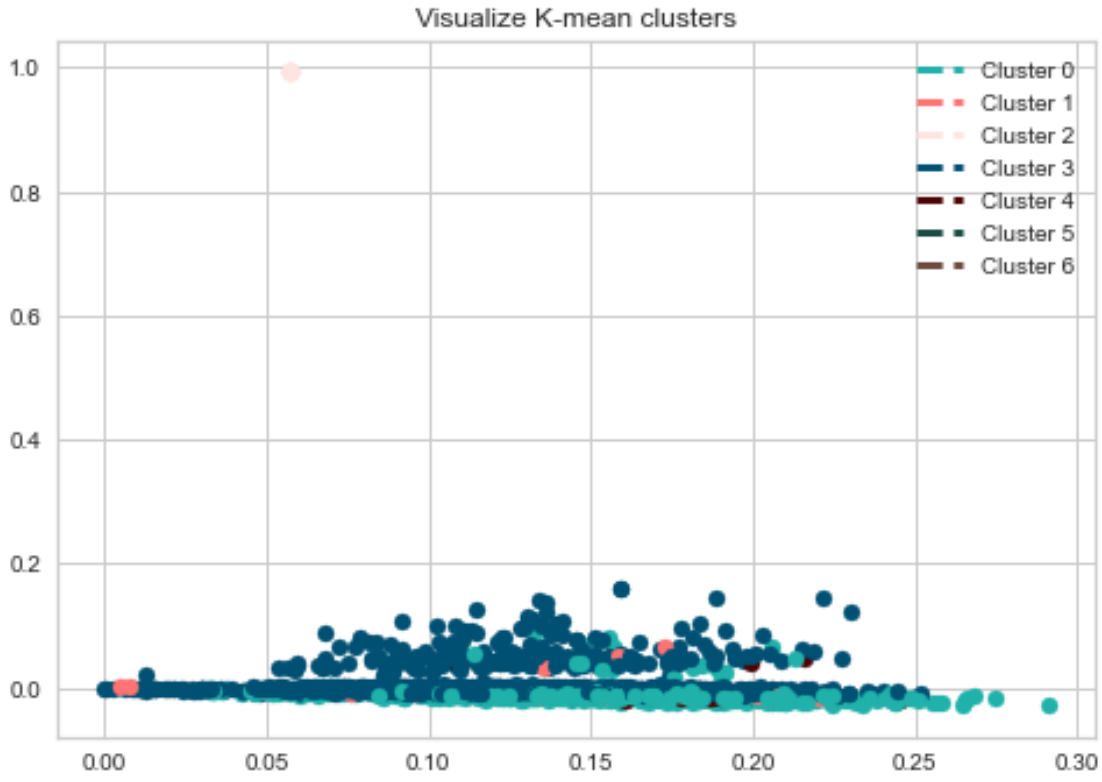
We use `TruncatedSVD` to decompose `tfidf_matrix`, because the matrix is too fat to plot it directly and `TruncatedSVD` works well with sparse data. We then attempt to plot the clusters with 2 components.

[ ]:
```
from sklearn.decomposition import TruncatedSVD

labels_color_map = {
    0: '#20b2aa', 1: '#ff7373', 2: '#ffe4e1', 3: '#005073', 4: '#4d0404', 5:␣
 ↪'#1b4b43', 6:'#6c4a3f'}

svd = TruncatedSVD(n_components=2)
reduced_matrix = svd.fit_transform(tfidf_matrix)
print(reduced_matrix.shape)
```

```
(181941, 2)
```

[ ]:
```
#slice the matrix even more
rr_matrix = reduced_matrix[:3000,:]
```

```
[ ]: from matplotlib.lines import Line2D

fig, ax = plt.subplots()
lines = [Line2D([0], [0], color=c, linewidth=3, linestyle='--') for c in␣
 ↪labels_color_map.values()]
for index, instance in enumerate(rr_matrix):
    pca_comp_1, pca_comp_2 = rr_matrix[index]
    color = labels_color_map[clusters[index]]
    ax.scatter(pca_comp_1, pca_comp_2, c=color)
plt.title('Visualize K-mean clusters')
plt.legend(lines, ['Cluster 0', 'Cluster 1','Cluster 2','Cluster 3','Cluster␣
 ↪4', 'Cluster 5', 'Cluster 6'])
plt.show()
```



However, since the reduced matrix after `TruncatedSVD` is still too big to plot, we slice it into 3000 data points. Therefore, some clusters are not inlcuded. From the visualization, it seems that the data isn't accurately clustered. However, it can because of over reduced and slicing of it, or 2 components aren't the right numbers of dimensions to visualize it.

LDA

April 23, 2022

1 Topic Modeling: Latent Dirichlet Allocation (LDA)

Topic modeling is a type of statistical modeling for discovering the abstract "topics" that occur in a collection of documents, and Latent Dirichlet Allocation (LDA) is one of the method. LDA is a generative probabilistic model that assumes each topic is a mixture over an underlying set of words, and each document is a mixture of over a set of topic probabilities.

Main idea - Every documents is a mixture of topics. e.g. Document 1 is 90% topic A and 10% topic B, while Document 2 is 30% topic A and 70% topic B.

- Every topic is a mixture of words. e.g. two-topic model of American news, with one topic for "politics" and one for "entertainment." The most common words in the politics topic might be "President", "Congress", and "government", while the entertainment topic may be made up of words such as "movies", "television", and "actor".

Three main parts of LDA

1. Dimensionality Reduction: Rather than representing a text T in its feature space as `{Word_i: count(Word_i, T) for Word_i in Vocabulary}`, you can represent it in a topic space as `{Topic_i: Weight(Topic_i, T) for Topic_i in Topics}`.
2. Unsupervised Learning: By doing topic modeling, we build clusters of words rather than clusters of texts. A text is thus a mixture of all the topics, each having a specific weight.
3. Tagging: abstract "topics" that occur in a collection of documents that best represents the information in them.

- psi, the distribution of words for each topic K
- phi, the distribution of topics for each document i
- α: parameter is Dirichlet prior concentration parameter that represents document-topic density — with a higher alpha, documents are assumed to be made up of more topics and result in more specific topic distribution per document.
- β: is the same prior concentration parameter that represents topic-word density — with high beta, topics are assumed to made of up most of the words and result in a more specific word distribution per topic.

2 Import data

[ ]:
```
import numpy as np
import pandas as pd
import sklearn
import seaborn as sns
import matplotlib.pyplot as plt
```

[ ]:
```
df = pd.read_csv('processed_response.zip')
```

- what is lambda?
- how to intperpret the result of the topics?

2.1 Running LDA using bags of words

[ ]:
```
import gensim
import gensim.corpora as corpora
```

[ ]:
```
from ast import literal_eval

#convert the response to a list
df['clean_responses'] = df['clean_responses'].apply(literal_eval)
```

[ ]:
```
# Create Dictionary
id2word = corpora.Dictionary(df['clean_responses'])

# Create Corpus
texts = df['clean_responses']

# Term Document Frequency
corpus = [id2word.doc2bow(text) for text in texts]

print(corpus[0])
```

```
[(0, 1), (1, 1), (2, 1), (3, 1), (4, 1), (5, 1), (6, 1), (7, 2), (8, 1), (9, 1),
(10, 1), (11, 1), (12, 1), (13, 1), (14, 1), (15, 1), (16, 1), (17, 1), (18, 1),
(19, 1), (20, 1), (21, 1), (22, 1), (23, 1)]
```

[ ]:
```
#times a word appears
corpus_0 = corpus[0]
for i in range(len(corpus_0)):
    print("Word {} (\"{}\") appears {} time.".format(corpus_0[i][0],␣
 ↪id2word[corpus_0[i][0]], corpus_0[i][1]))
```

```
Word 0 ("abstract") appears 1 time.
Word 1 ("answer") appears 1 time.
Word 2 ("approach") appears 1 time.
Word 3 ("attack") appears 1 time.
Word 4 ("construct") appears 1 time.
```

```
Word 5 ("focus") appears 1 time.
Word 6 ("form") appears 1 time.
Word 7 ("framework") appears 2 time.
Word 8 ("good") appears 1 time.
Word 9 ("hard") appears 1 time.
Word 10 ("instead") appears 1 time.
Word 11 ("knowledg") appears 1 time.
Word 12 ("matt") appears 1 time.
Word 13 ("moral") appears 1 time.
Word 14 ("plato") appears 1 time.
Word 15 ("poll") appears 1 time.
Word 16 ("preparatori") appears 1 time.
Word 17 ("set") appears 1 time.
Word 18 ("specif") appears 1 time.
Word 19 ("strength") appears 1 time.
Word 20 ("veri") appears 1 time.
Word 21 ("weak") appears 1 time.
Word 22 ("whole") appears 1 time.
Word 23 ("would") appears 1 time.
```

In `corpus`, every tuple represent (index of the word, frequency), which is shown above.

[ ]:
```
from pprint import pprint
# number of topics
num_topics = 10
# Build LDA model
lda_model = gensim.models.LdaMulticore(corpus=corpus,
                                       id2word=id2word,
                                       num_topics=num_topics)
# Print the Keyword in the 10 topics
pprint(lda_model.print_topics())
```

```
[(0,
  '0.013*"would" + 0.011*"becaus" + 0.009*"one" + 0.007*"use" + 0.007*"make" + '
  '0.006*"like" + 0.006*"chang" + 0.006*"differ" + 0.005*"data" + '
  '0.005*"increas"'),
 (1,
  '0.016*"system" + 0.011*"would" + 0.008*"level" + 0.007*"think" + '
  '0.007*"individu" + 0.007*"understand" + 0.007*"peopl" + 0.007*"one" + '
  '0.007*"differ" + 0.006*"exampl"'),
 (2,
  '0.012*"would" + 0.011*"model" + 0.009*"one" + 0.009*"use" + 0.009*"valu" + '
  '0.008*"n" + 0.008*"p" + 0.008*"time" + 0.008*"becaus" + 0.007*"differ"'),
 (3,
  '0.014*"use" + 0.013*"x" + 0.010*"studi" + 0.009*"would" + 0.009*"one" + '
  '0.008*"becaus" + 0.007*"research" + 0.007*"understand" + 0.007*"also" + '
  '0.007*"think"'),
 (4,
  '0.010*"would" + 0.010*"use" + 0.009*"could" + 0.009*"product" + '
```

```
 '0.007*"like" + 0.006*"becaus" + 0.006*"risk" + 0.006*"also" + '
 '0.006*"market" + 0.006*"compani"'),
(5,
 '0.011*"use" + 0.008*"becaus" + 0.007*"state" + 0.007*"would" + '
 '0.006*"differ" + 0.006*"think" + 0.005*"problem" + 0.005*"chang" + '
 '0.005*"peopl" + 0.005*"exampl"'),
(6,
 '0.018*"use" + 0.011*"data" + 0.009*"variabl" + 0.008*"make" + '
 '0.007*"becaus" + 0.007*"line" + 0.007*"would" + 0.006*"one" + 0.006*"show" '
 '+ 0.006*"exampl"'),
(7,
 '0.010*"would" + 0.010*"compani" + 0.008*"differ" + 0.007*"peopl" + '
 '0.007*"work" + 0.006*"time" + 0.006*"use" + 0.005*"one" + 0.005*"becaus" + '
 '0.005*"exampl"'),
(8,
 '0.012*"peopl" + 0.009*"one" + 0.009*"theori" + 0.007*"becaus" + '
 '0.006*"level" + 0.006*"make" + 0.005*"differ" + 0.005*"exampl" + '
 '0.005*"polit" + 0.005*"social"'),
(9,
 '0.012*"argument" + 0.012*"problem" + 0.011*"use" + 0.011*"evid" + '
 '0.009*"make" + 0.008*"becaus" + 0.007*"would" + 0.007*"think" + '
 '0.007*"bias" + 0.006*"exampl"')]
```

From the Topic 0 is a represented as 0.013*"would" + 0.011*"becaus" + 0.009*"one" + 0.007*"use" + 0.007*"make" + 0.006*"like" + 0.006*"chang" + 0.006*"differ" + 0.005*"data" + 0.005*"increas." It means the top 10 keywords that contribute to this topic are: would, becaus, one.. and so on and the weight of would on topic 0 is 0.013.

[ ]:
```
#print the top 20 words in each topics
topics_matrix = lda_model.show_topics(formatted=False, num_words=20)
topics_matrix = np.array(topics_matrix)
topic_words = topics_matrix[:,1]

for i in topic_words:
    print([str(word[0]) for word in i])
    print()
```

```
['would', 'becaus', 'one', 'use', 'make', 'like', 'chang', 'differ', 'data',
'increas', 'mean', 'exampl', 'group', 'c', 'also', 'need', 'think', 'v',
'activ', 'water']

['system', 'would', 'level', 'think', 'individu', 'understand', 'peopl', 'one',
'differ', 'exampl', 'effect', 'complex', 'need', 'interact', 'becaus', 'also',
'group', 'social', 'market', 'motiv']

['would', 'model', 'one', 'use', 'valu', 'n', 'p', 'time', 'becaus', 'differ',
'number', 'probabl', 'b', 'distribut', 'x', 'function', 'first', 'data', 'case',
'also']
```

```
['use', 'x', 'studi', 'would', 'one', 'becaus', 'research', 'understand',
'also', 'think', 'differ', 'effect', 'need', 'help', 'way', 'could', 'make',
'hypothesi', 'test', 'data']

['would', 'use', 'could', 'product', 'like', 'becaus', 'risk', 'also', 'market',
'compani', 'think', 'one', 'us', 'creat', 'make', 'invest', 'differ', 'countri',
'increas', 'idea']

['use', 'becaus', 'state', 'would', 'differ', 'think', 'problem', 'chang',
'peopl', 'exampl', 'one', 'way', 'mean', 'make', 'also', 'class', 'hypothesi',
'could', 'structur', 'network']

['use', 'data', 'variabl', 'make', 'becaus', 'line', 'would', 'one', 'show',
'exampl', 'activ', 'mean', 'bias', 'word', 'point', 'could', 'like', 'control',
'also', 'differ']

['would', 'compani', 'differ', 'peopl', 'work', 'time', 'use', 'one', 'becaus',
'exampl', 'like', 'also', 'make', 'could', 'valu', 'interest', 'way', 'market',
'help', 'chang']

['peopl', 'one', 'theori', 'becaus', 'level', 'make', 'differ', 'exampl',
'polit', 'social', 'would', 'cultur', 'societi', 'human', 'person', 'individu',
'way', 'base', 'govern', 'moral']

['argument', 'problem', 'use', 'evid', 'make', 'becaus', 'would', 'think',
'bias', 'exampl', 'state', 'also', 'thesi', 'one', 'differ', 'way', 'claim',
'solut', 'base', 'effect']


/var/folders/0h/xyv81g2n7sj6zr0c9cw30gkc0000gn/T/ipykernel_13803/4262890021.py:3
: VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences
(which is a list-or-tuple of lists-or-tuples-or ndarrays with different lengths
or shapes) is deprecated. If you meant to do this, you must specify
'dtype=object' when creating the ndarray.
  topics_matrix = np.array(topics_matrix)
```

[ ]:
```
#visualize the result

import pyLDAvis
# import pyLDAvis.gensim
import pyLDAvis.gensim_models as gensimvis
import os
import pickle

# Visualize the topics
pyLDAvis.enable_notebook()
```

[ ]:
```
LDAvis_prepared = gensimvis.prepare(lda_model, corpus, id2word)
```

```
  if LooseVersion(np.__version__) < '1.13':
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/setuptools/_distutils/version.py:351: DeprecationWarning: distutils
Version classes are deprecated. Use packaging.version instead.
  other = LooseVersion(other)
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/joblib/backports.py:36: DeprecationWarning: distutils Version classes
are deprecated. Use packaging.version instead.
  if LooseVersion(np.__version__) < '1.13':
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/setuptools/_distutils/version.py:351: DeprecationWarning: distutils
Version classes are deprecated. Use packaging.version instead.
  other = LooseVersion(other)
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/joblib/backports.py:36: DeprecationWarning: distutils Version classes
are deprecated. Use packaging.version instead.
  if LooseVersion(np.__version__) < '1.13':
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/setuptools/_distutils/version.py:351: DeprecationWarning: distutils
Version classes are deprecated. Use packaging.version instead.
  other = LooseVersion(other)
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/joblib/backports.py:36: DeprecationWarning: distutils Version classes
are deprecated. Use packaging.version instead.
  if LooseVersion(np.__version__) < '1.13':
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/setuptools/_distutils/version.py:351: DeprecationWarning: distutils
Version classes are deprecated. Use packaging.version instead.
  other = LooseVersion(other)
```

[ ]:
```
pyLDAvis.display(LDAvis_prepared)
```

[ ]:
```
<IPython.core.display.HTML object>
```

The relevance metric: λ

- $\lambda = 1$: ranking soley by probability is decending order
- $\lambda = 0$: ranking soley by the lift. lift = the ratio of a term's probability within a topic to its marginal probability across the corpus. It generally decreases with globally frequent terms. But it can be noisy too if the rare terms only occur in one single topic.

$P(T|w)$: the likelihood that observed word w was generated by latent topic T. We use it to determine how informative a specific word w can inform the topics. If word tells little of the topic mixture it will receive a low distinctiveness score.

[ ]:
```
pyLDAvis.save_html(LDAvis_prepared, 'lda.html')
```

2.2 Running LDA using tf-idf

[ ]:
```
from gensim import corpora, models

tfidf = models.TfidfModel(corpus)
corpus_tfidf = tfidf[corpus]

# Build LDA model on tf-idf
lda_model_tf = gensim.models.LdaMulticore(corpus=corpus_tfidf,
                                          id2word=id2word,
                                          num_topics=num_topics)
# Print the Keyword in the 10 topics
pprint(lda_model_tf.print_topics())
```

```
[(0,
  '0.004*"system" + 0.004*"peopl" + 0.003*"differ" + 0.003*"level" + '
  '0.003*"one" + 0.003*"emot" + 0.003*"would" + 0.003*"think" + '
  '0.003*"understand" + 0.003*"interact"'),
 (1,
  '0.009*"problem" + 0.005*"solut" + 0.004*"solv" + 0.004*"use" + '
  '0.003*"think" + 0.003*"constraint" + 0.003*"would" + 0.003*"differ" + '
  '0.003*"goal" + 0.003*"help"'),
 (2,
  '0.009*"x" + 0.006*"data" + 0.006*"variabl" + 0.006*"distribut" + '
  '0.006*"sampl" + 0.005*"probabl" + 0.005*"valu" + 0.005*"model" + 0.004*"p" '
  '+ 0.004*"would"'),
 (3,
  '0.003*"would" + 0.003*"compani" + 0.003*"peopl" + 0.003*"market" + '
  '0.003*"differ" + 0.003*"think" + 0.002*"make" + 0.002*"one" + 0.002*"use" + '
  '0.002*"need"'),
 (4,
  '0.009*"poll" + 0.009*"student" + 0.008*"complet" + 0.008*"https" + '
  '0.007*"present" + 0.007*"com" + 0.007*"googl" + 0.007*"doc" + 0.006*"edit" '
  '+ 0.006*"document"'),
 (5,
  '0.007*"n" + 0.004*"would" + 0.004*"node" + 0.004*"algorithm" + 0.003*"tree" '
  '+ 0.003*"time" + 0.003*"number" + 0.003*"use" + 0.003*"one" + 0.003*"list"'),
 (6,
  '0.003*"would" + 0.002*"co" + 0.002*"x" + 0.002*"increas" + 0.002*"water" + '
  '0.002*"becaus" + 0.002*"chang" + 0.002*"system" + 0.002*"use" + '
  '0.002*"peopl"'),
 (7,
  '0.006*"compani" + 0.004*"market" + 0.003*"product" + 0.003*"would" + '
  '0.003*"use" + 0.003*"custom" + 0.003*"risk" + 0.003*"cost" + 0.003*"make" + '
  '0.002*"think"'),
 (8,
```

```
  '0.003*"would" + 0.003*"use" + 0.003*"energi" + 0.002*"effect" + '
  '0.002*"becaus" + 0.002*"differ" + 0.002*"water" + 0.002*"one" + '
  '0.002*"cell" + 0.002*"observ"'),
 (9,
  '0.007*"argument" + 0.006*"evid" + 0.005*"p" + 0.005*"hypothesi" + 0.004*"b" '
  '+ 0.004*"induct" + 0.004*"thesi" + 0.004*"c" + 0.004*"true" + 0.004*"use"')]
```

[ ]:
```
#print the top 20 words in each topics
topics_matrix = lda_model_tf.show_topics(formatted=False, num_words=20)
topics_matrix = np.array(topics_matrix)
topic_words = topics_matrix[:,1]

for i in topic_words:
    print([str(word[0]) for word in i])
    print()
```

```
['system', 'peopl', 'differ', 'level', 'one', 'emot', 'would', 'think',
'understand', 'interact', 'use', 'individu', 'cultur', 'becaus', 'agent',
'social', 'way', 'exampl', 'emerg', 'make']

['problem', 'solut', 'solv', 'use', 'think', 'constraint', 'would', 'differ',
'goal', 'help', 'one', 'process', 'understand', 'need', 'appli', 'level',
'becaus', 'could', 'identifi', 'activ']

['x', 'data', 'variabl', 'distribut', 'sampl', 'probabl', 'valu', 'model', 'p',
'would', 'mean', 'use', 'function', 'treatment', 'vector', 'calcul', 'differ',
'number', 'test', 'random']

['would', 'compani', 'peopl', 'market', 'differ', 'think', 'make', 'one', 'use',
'need', 'strategi', 'becaus', 'system', 'could', 'product', 'countri', 'also',
'chang', 'effect', 'group']

['poll', 'student', 'complet', 'https', 'present', 'com', 'googl', 'doc',
'edit', 'document', 'usp', 'share', 'would', 'use', 'argument', 'think',
'becaus', 'one', 'make', 'could']

['n', 'would', 'node', 'algorithm', 'tree', 'time', 'number', 'use', 'one',
'list', 'becaus', 'valu', 'sort', 'first', 'make', 'x', 'optim', 'case', 'row',
'think']

['would', 'co', 'x', 'increas', 'water', 'becaus', 'chang', 'system', 'use',
'peopl', 'one', 'differ', 'carbon', 'time', 'histogram', 'earth', 'state',
'temperatur', 'citi', 'could']

['compani', 'market', 'product', 'would', 'use', 'custom', 'risk', 'cost',
'make', 'think', 'peopl', 'invest', 'price', 'activ', 'rate', 'differ',
'financi', 'also', 'becaus', 'busi']
```

```
['would', 'use', 'energi', 'effect', 'becaus', 'differ', 'water', 'one', 'cell',
'observ', 'test', 'could', 'chang', 'hypothesi', 'increas', 'complianc', 'like',
'theori', 'time', 'level']

['argument', 'evid', 'p', 'hypothesi', 'b', 'induct', 'thesi', 'c', 'true',
'use', 'data', 'conclus', 'valid', 'premis', 'deduct', 'sentenc', 'logic',
'theori', 'test', 'q']
```

```
/var/folders/0h/xyv81g2n7sj6zr0c9cw30gkc0000gn/T/ipykernel_13803/697313039.py:3:
VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences
(which is a list-or-tuple of lists-or-tuples-or ndarrays with different lengths
or shapes) is deprecated. If you meant to do this, you must specify
'dtype=object' when creating the ndarray.
  topics_matrix = np.array(topics_matrix)
```

[ ]:
```
LDAvis_prepared_tf = gensimvis.prepare(lda_model_tf, corpus_tfidf, id2word)
```

```
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
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packages/setuptools/_distutils/version.py:351: DeprecationWarning: distutils
Version classes are deprecated. Use packaging.version instead.
```

```
    other = LooseVersion(other)
```

[ ]:
```
pyLDAvis.display(LDAvis_prepared_tf)
```

[ ]:
```
<IPython.core.display.HTML object>
```

[ ]:
```
pyLDAvis.save_html(LDAvis_prepared_tf, 'lda_tf.html')
```

3 Select the best number of clusters by coherence score

We can coherence score in topic modeling to measure how interpretable the topics are to humans. We select the best number of clusters based on highest coherence score.

[ ]:
```
from gensim.models import CoherenceModel

# Compute Coherence Score
coherence_model_lda = CoherenceModel(model=lda_model, texts=texts,␣
 ↪dictionary=id2word, coherence='c_v')
coherence_lda = coherence_model_lda.get_coherence()
print('Coherence Score bag of words: ', coherence_lda)

coherence_model_lda = CoherenceModel(model=lda_model_tf, texts=texts,␣
 ↪dictionary=id2word, coherence='c_v')
coherence_lda_tf = coherence_model_lda.get_coherence()
print('Coherence Score tf-idf: ', coherence_lda_tf)
```

```
Coherence Score bag of words:  0.33813657622075743
Coherence Score tf-idf:  0.3884673157891732
```

[ ]:
```
num_list = list(range(2,11))
coherence = {}
for num_topics in num_list:
    lda_model_tf = gensim.models.LdaMulticore(corpus=corpus_tfidf,
                                              id2word=id2word,
                                              num_topics=num_topics)
    coherence_model_lda = CoherenceModel(model=lda_model_tf, texts=texts,␣
 ↪dictionary=id2word, coherence='c_v')
    coherence_lda = coherence_model_lda.get_coherence()
    coherence[num_topics] = coherence_lda
```

[ ]:
```
coherence
```

[ ]:
```
{2: 0.29721896496192934,
 3: 0.31396921106978004,
 4: 0.34535485103863095,
 5: 0.2559763428291707,
 6: 0.3195102597091959,
 7: 0.3465651203928427,
```

```
 8: 0.3767523695290471,
 9: 0.3953096197373716,
 10: 0.38321805318943086}
```

The next can be tuning the hyperparameters for alpha and beta. - Evaluate Topic Models: Latent Dirichlet Allocation (LDA)

[ ]:
```
n = 9

# Build LDA model on tf-idf
lda_model_tf = gensim.models.LdaMulticore(corpus=corpus_tfidf,
                                          id2word=id2word,
                                          num_topics= n)
# Print the Keyword in the 10 topics
pprint(lda_model_tf.print_topics())
```

```
[(0,
  '0.004*"data" + 0.004*"use" + 0.004*"studi" + 0.003*"would" + 0.003*"think" '
  '+ 0.003*"make" + 0.003*"one" + 0.003*"differ" + 0.003*"bias" + '
  '0.003*"audienc"'),
 (1,
  '0.004*"art" + 0.003*"music" + 0.003*"moral" + 0.002*"use" + 0.002*"cultur" '
  '+ 0.002*"would" + 0.002*"peopl" + 0.002*"think" + 0.002*"differ" + '
  '0.002*"one"'),
 (2,
  '0.004*"variabl" + 0.004*"attent" + 0.004*"memori" + 0.004*"line" + '
  '0.004*"data" + 0.003*"slope" + 0.003*"regress" + 0.003*"would" + '
  '0.003*"process" + 0.003*"correl"'),
 (3,
  '0.006*"system" + 0.005*"problem" + 0.004*"model" + 0.003*"level" + '
  '0.003*"differ" + 0.003*"agent" + 0.003*"use" + 0.003*"interact" + '
  '0.003*"complex" + 0.003*"solut"'),
 (4,
  '0.013*"x" + 0.009*"n" + 0.007*"p" + 0.005*"b" + 0.005*"valu" + '
  '0.005*"function" + 0.005*"number" + 0.004*"tree" + 0.004*"f" + '
  '0.004*"probabl"'),
 (5,
  '0.006*"student" + 0.005*"poll" + 0.004*"complet" + 0.004*"present" + '
  '0.003*"peopl" + 0.003*"would" + 0.003*"countri" + 0.002*"differ" + '
  '0.002*"becaus" + 0.002*"use"'),
 (6,
  '0.004*"peopl" + 0.003*"leader" + 0.003*"would" + 0.003*"one" + '
  '0.003*"state" + 0.003*"power" + 0.002*"system" + 0.002*"individu" + '
  '0.002*"becaus" + 0.002*"think"'),
 (7,
  '0.005*"thesi" + 0.005*"argument" + 0.004*"evid" + 0.004*"use" + 0.003*"flu" '
  '+ 0.003*"clone" + 0.003*"would" + 0.002*"make" + 0.002*"effect" + '
  '0.002*"becaus"'),
```

```
 (8,
  '0.007*"compani" + 0.006*"market" + 0.005*"product" + 0.004*"custom" + '
  '0.004*"risk" + 0.004*"valu" + 0.004*"cost" + 0.004*"would" + 0.004*"price" '
  '+ 0.003*"rate"')]
```

[ ]:
```
#print the top 20 words in each topics
topics_matrix = lda_model_tf.show_topics(formatted=False, num_words=20)
topics_matrix = np.array(topics_matrix)
topic_words = topics_matrix[:,1]

for i in topic_words:
    print([str(word[0]) for word in i])
    print()
```

```
['data', 'use', 'studi', 'would', 'think', 'make', 'one', 'differ', 'bias',
'audienc', 'hypothesi', 'research', 'could', 'understand', 'googl', 'design',
'variabl', 'effect', 'becaus', 'test']

['art', 'music', 'moral', 'use', 'cultur', 'would', 'peopl', 'think', 'differ',
'one', 'becaus', 'also', 'way', 'like', 'work', 'make', 'artist', 'understand',
'context', 'could']

['variabl', 'attent', 'memori', 'line', 'data', 'slope', 'regress', 'would',
'process', 'correl', 'use', 'brain', 'r', 'model', 'temperatur', 'co',
'increas', 'one', 'becaus', 'differ']

['system', 'problem', 'model', 'level', 'differ', 'agent', 'use', 'interact',
'complex', 'solut', 'would', 'one', 'emerg', 'solv', 'properti', 'becaus',
'understand', 'think', 'could', 'state']

['x', 'n', 'p', 'b', 'valu', 'function', 'number', 'tree', 'f', 'probabl',
'distribut', 'algorithm', 'vector', 'c', 'node', 'would', 'matrix', 'z', 'use',
'time']

['student', 'poll', 'complet', 'present', 'peopl', 'would', 'countri', 'differ',
'becaus', 'use', 'think', 'one', 'social', 'chang', 'econom', 'like', 'could',
'class', 'effect', 'exampl']

['peopl', 'leader', 'would', 'one', 'state', 'power', 'system', 'individu',
'becaus', 'think', 'level', 'differ', 'polit', 'group', 'govern', 'social',
'chang', 'make', 'exampl', 'could']

['thesi', 'argument', 'evid', 'use', 'flu', 'clone', 'would', 'make', 'effect',
'becaus', 'word', 'one', 'exampl', 'organ', 'think', 'support', 'statement',
'claim', 'c', 'reader']

['compani', 'market', 'product', 'custom', 'risk', 'valu', 'cost', 'would',
'price', 'rate', 'busi', 'invest', 'increas', 'financi', 'strategi', 'growth',
```

```
'differ', 'becaus', 'need', 'brand']
```

```
/var/folders/0h/xyv81g2n7sj6zr0c9cw30gkc0000gn/T/ipykernel_13803/697313039.py:3:
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```

[ ]:
```
LDAvis_prepared_tf = gensimvis.prepare(lda_model_tf, corpus_tfidf, id2word)
```

```
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/pyLDAvis/_prepare.py:246: FutureWarning: In a future version of pandas
all arguments of DataFrame.drop except for the argument 'labels' will be
keyword-only
  default_term_info = default_term_info.sort_values(
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
packages/past/builtins/misc.py:45: DeprecationWarning: the imp module is
deprecated in favour of importlib; see the module's documentation for
alternative uses
  from imp import reload
/Users/swimmingcircle/Library/Python/3.9/lib/python/site-
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```

[ ]:
```
pyLDAvis.display(LDAvis_prepared_tf)
pyLDAvis.save_html(LDAvis_prepared_tf, '9_lda_tf.html')
```