In [3]:

```
%matplotlib inline

import pandas as pd

import matplotlib.pyplot as plt

from textblob import TextBlob

import sklearn

import numpy as np

from sklearn.feature_extraction.text import CountVectorizer

from sklearn.naive_bayes import MultinomialNB

from sklearn.metrics import classification_report, f1_score, accuracy_score, confusion
_matrix


np.random.seed(47)
```

In [4]:

```
reviews = pd.read_csv('DataScienceJobsResumes.csv', encoding = 'unicode_escape')
```

In [6]:

```
print(reviews.head())

print(reviews.tail())
```

```
                              jobOrResumeDescription            role  \
0  : Artificial Intelligence / Machine Learning D...       Developer   
1   : Data Scientist/Architect\n: 6+ months + Hig...  Data Scientist   
2   : Data Analyst\n: Davidson, NC\n: 04+ Months\...    Data Analyst   
3   : Big Data Architect or Data Scientist\n: New...  Data Scientist   
4  : Data Engineer\n: Woonsocket, RI\n: 6+ Months...   Data Engineer   

      sourceType  
0  job recruiter  
1  job recruiter  
2  job recruiter  
3  job recruiter  
4  job recruiter  
                                jobOrResumeDescription            role  \
196  \n\n and Experience:\n* Ten years of experienc...  Data Scientist   
197   \n \n~  and  ~\n \t \n- Python \t- \tMolecula...  Data Scientist   
198  M.S. Statistics graduate looking for a full-ti...  Data Scientist   
199  \nI□m a data scientist with a background in ne...  Data Scientist   
200  \n:\n* Machine learning in R, and other softwa...  Data Scientist   

    sourceType  
196     resume  
197     resume  
198     resume  
199     resume  
200     resume  
```

In [8]:

```
print(reviews.shape)
```

```
(201, 3)
```

In [9]:

```
import regex
def preprocessor(text):
    text = regex.sub('<[^>]*>', '', text)
    emoticons = regex.findall('(?::|;|=)(?:-)?(?:\)|\(|D|P)', text)
    text = regex.sub('[\W]+', ' ', text.lower()) +\
        ' '.join(emoticons).replace('-', '')
    return text
```

In [10]:

```
reviews.tail()
```

Out[10]:

	jobOrResumeDescription	role	sourceType
196	\n\n and Experience:\n* Ten years of experienc...	Data Scientist	resume
197	\n \n~ and ~\n \t \n- Python \t- \tMolecula...	Data Scientist	resume
198	M.S. Statistics graduate looking for a full-ti...	Data Scientist	resume
199	\nI’ m a data scientist with a background in ne...	Data Scientist	resume
200	\n:\n* Machine learning in R, and other softwa...	Data Scientist	resume

In [11]:

```
import numpy as np


reviews = reviews.reindex(np.random.permutation(reviews.index))


print(reviews.head())
print(reviews.tail())
```

```
                                jobOrResumeDescription            role  \
5    PhD or MS with 3 years post MS experience Comp...  Data Scientist
156  * A data scientist  with 7 years of progressiv...  Data Scientist
0    : Artificial Intelligence / Machine Learning D...       Developer
99   Senior Data Scientist\nKareo Inc2 re - Irvine,...  Data Scientist
187  My life  experience has been in assistant mana...  Data Scientist

        sourceType
5    job recruiter
156         resume
0    job recruiter
99        Job post
187         resume
                                jobOrResumeDescription            role  \
72   Senior Healthcare Data Analyst\nAdvantmed98 re...    Data Analyst
8    Research Computing SME - 19-03563\n \n\n    : ...  Data Scientist
71   Sr Financial Analyst\nApria Healthcare1,853 re...    Data Analyst
134  ? Highly productive and effective Financial An...  Data Scientist
135  Business Data Analyst who maximizes productivi...  Data Scientist

        sourceType
72        Job post
8    job recruiter
71        Job post
134         resume
135         resume
```

In [12]:

```
reviews.groupby('sourceType').describe()
```

Out[12]:

	jobOrResumeDescription				role			
	count	**unique**	**top**	**freq**	**count**	**unique**	**top**	**freq**
sourceType								
Job post	59	58	Senior Data Analyst\nKelly Services14,506 re -...	2	59	3	Data Analyst	41
job recruiter	42	42	: Big Data Lead\n\n: Raritan- NJ\n\n: -12 mont...	1	42	5	Data Scientist	17
resume	100	100	M.S. Statistics graduate looking for a full-ti...	1	100	1	Data Scientist	100

In [13]:

```
reviews.groupby('role').describe()
```

Out[13]:

	jobOrResumeDescription				sourceType			
	count	**unique**	**top**	**freq**	**count**	**unique**	**top**	**freq**
role								
Data Analyst	49	48	Senior Data Analyst\nKelly Services14,506 re -...	2	49	2	Job post	41
Data Engineer	13	13	\n and Key : Data Engineer, Python, SQL and U...	1	13	2	job recruiter	8
Data Scientist	130	130	\n* Dedicated IT with around7 years of exper...	1	130	3	resume	100
Developer	8	8	: Hadoop Developer\n\n: SFO, CA / Bentonville,...	1	8	1	job recruiter	8
Software Engineer	1	1	Ref. : 19-62193\n ...	1	1	1	job recruiter	1

In [14]:

```
reviews['length'] = reviews['jobOrResumeDescription'].map(lambda text: len(text))
print(reviews.head())
```

```
                                jobOrResumeDescription            role  \
5    PhD or MS with 3 years post MS experience Comp...  Data Scientist
156  * A data scientist  with 7 years of progressiv...  Data Scientist
0    : Artificial Intelligence / Machine Learning D...       Developer
```

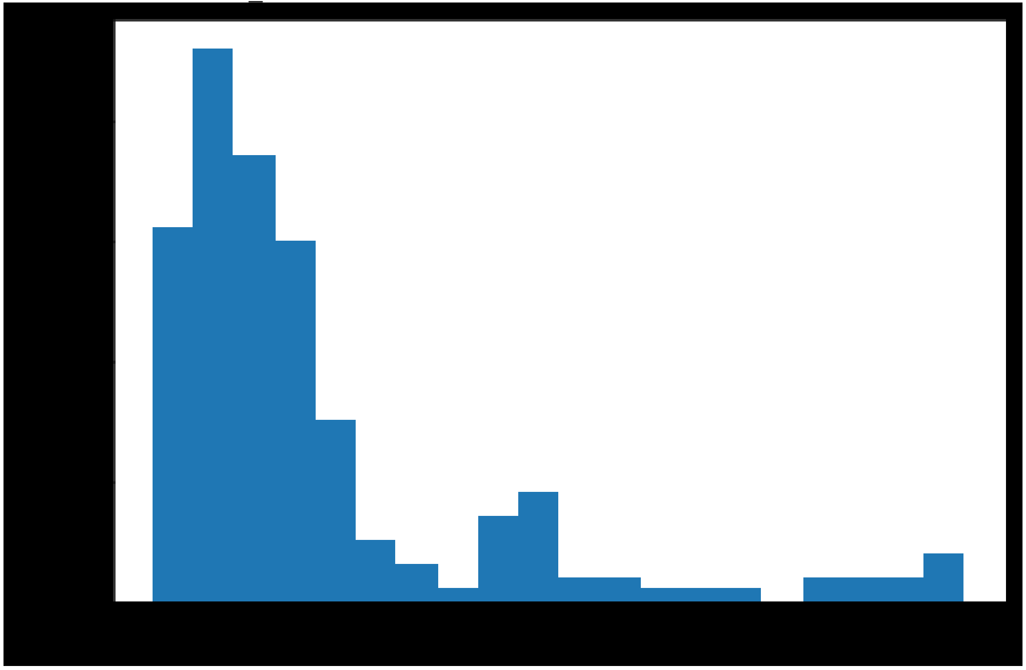
```
99   Senior Data Scientist\nKareo Inc2 re - Irvine,...  Data Scientist
187  My life  experience has been in assistant mana...  Data Scientist

           sourceType  length
5    job recruiter     801
156         resume   22827
0    job recruiter     909
99        Job post    4129
187         resume    4127
```

In [15]:

```
reviews.length.plot(bins=20, kind='hist')
```

Out[15]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x22adc045208>
```



In [16]:

```
reviews.length.describe()
```

Out[16]:

```
count      201.000000
mean      5694.482587
std       5759.567865
min        303.000000
25%       2202.000000
50%       3873.000000
75%       6120.000000
max      26846.000000
Name: length, dtype: float64
```

In [18]:

```
print(list(reviews.jobOrResumeDescription[reviews.length > 40].index))
print(list(reviews.role[reviews.length > 40]))
```

```
[5, 156, 0, 99, 187, 74, 128, 36, 160, 141, 132, 20, 63, 108, 16, 133, 25, 158, 96, 9,
1, 148, 62, 172, 15, 32, 112, 164, 45, 10, 154, 162, 168, 3, 13, 31, 183, 92, 82, 121,
192, 182, 26, 178, 193, 130, 190, 131, 83, 78, 40, 115, 69, 102, 37, 139, 149, 165, 47
, 85, 189, 35, 106, 42, 81, 46, 18, 107, 6, 155, 39, 64, 76, 77, 61, 188, 151, 70, 24,
111, 38, 91, 195, 67, 94, 54, 44, 11, 127, 119, 33, 170, 150, 200, 143, 145, 136, 117,
57, 29, 19, 116, 22, 126, 104, 58, 177, 171, 122, 197, 60, 88, 129, 191, 174, 110, 98,
105, 43, 49, 14, 194, 118, 103, 97, 167, 93, 30, 95, 181, 41, 152, 142, 17, 109, 120,
157, 138, 28, 100, 56, 12, 140, 185, 186, 146, 199, 124, 89, 176, 153, 175, 166, 144,
2, 75, 52, 84, 51, 90, 159, 86, 68, 125, 147, 21, 27, 161, 79, 137, 101, 163, 4, 66, 3
4, 73, 48, 53, 184, 169, 196, 180, 123, 87, 65, 114, 50, 55, 113, 173, 198, 7, 59, 23,
80, 179, 72, 8, 71, 134, 135]
['Data Scientist', 'Data Scientist', 'Developer', 'Data Scientist', 'Data Scientist',
'Data Analyst', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Scientist'
, 'Data Scientist', 'Data Scientist', 'Data Analyst', 'Data Scientist', 'Data Engineer
', 'Data Scientist', 'Data Engineer', 'Data Scientist', 'Data Scientist', 'Software En
gineer', 'Data Scientist', 'Data Scientist', 'Data Analyst', 'Data Scientist', 'Data A
nalyst', 'Data Analyst', 'Data Scientist', 'Data Scientist', 'Data Analyst', 'Develope
r', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Engi
neer', 'Developer', 'Data Scientist', 'Data Engineer', 'Data Analyst', 'Data Scientist
', 'Data Scientist', 'Data Scientist', 'Developer', 'Data Scientist', 'Data Scientist'
, 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Analyst', 'Data Analyst'
, 'Data Engineer', 'Data Scientist', 'Data Analyst', 'Data Scientist', 'Data Engineer'
, 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Analyst', 'Data Scientis
t', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Developer', 'Data Analyst',
'Data Analyst', 'Developer', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Da
ta Scientist', 'Data Analyst', 'Data Analyst', 'Data Analyst', 'Data Analyst', 'Data S
cientist', 'Data Scientist', 'Data Analyst', 'Data Scientist', 'Data Scientist', 'Data
Analyst', 'Data Scientist', 'Data Scientist', 'Data Analyst', 'Data Engineer', 'Data A
nalyst', 'Data Analyst', 'Data Analyst', 'Data Scientist', 'Data Scientist', 'Data Sci
entist', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data
Scientist', 'Data Scientist', 'Data Scientist', 'Data Analyst', 'Data Analyst', 'Data
Scientist', 'Data Scientist', 'Developer', 'Data Scientist', 'Data Scientist', 'Data A
nalyst', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data
Analyst', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Dat
a Scientist', 'Data Engineer', 'Data Scientist', 'Data Analyst', 'Data Scientist', 'Da
ta Scientist', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Scientist',
'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Engineer', 'Data Scientist
', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Analyst', 'Data Scienti
st', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Engineer', 'Data Scie
ntist', 'Data Analyst', 'Data Engineer', 'Data Scientist', 'Data Scientist', 'Data Sci
entist', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data
Scientist', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'D
ata Analyst', 'Data Analyst', 'Data Analyst', 'Data Analyst', 'Data Analyst', 'Data En
gineer', 'Data Scientist', 'Data Scientist', 'Data Analyst', 'Data Scientist', 'Data S
cientist', 'Developer', 'Data Scientist', 'Data Scientist', 'Data Analyst', 'Data Scie
ntist', 'Data Scientist', 'Data Scientist', 'Data Engineer', 'Data Analyst', 'Data Sci
entist', 'Data Analyst', 'Data Analyst', 'Data Analyst', 'Data Scientist', 'Data Scien
tist', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data Scientist', 'Data A
nalyst', 'Data Scientist', 'Data Analyst', 'Data Analyst', 'Data Scientist', 'Data Sci
entist', 'Data Scientist', 'Data Scientist', 'Data Analyst', 'Data Analyst', 'Data Ana
lyst', 'Data Scientist', 'Data Analyst', 'Data Scientist', 'Data Analyst', 'Data Scien
tist', 'Data Scientist']
```

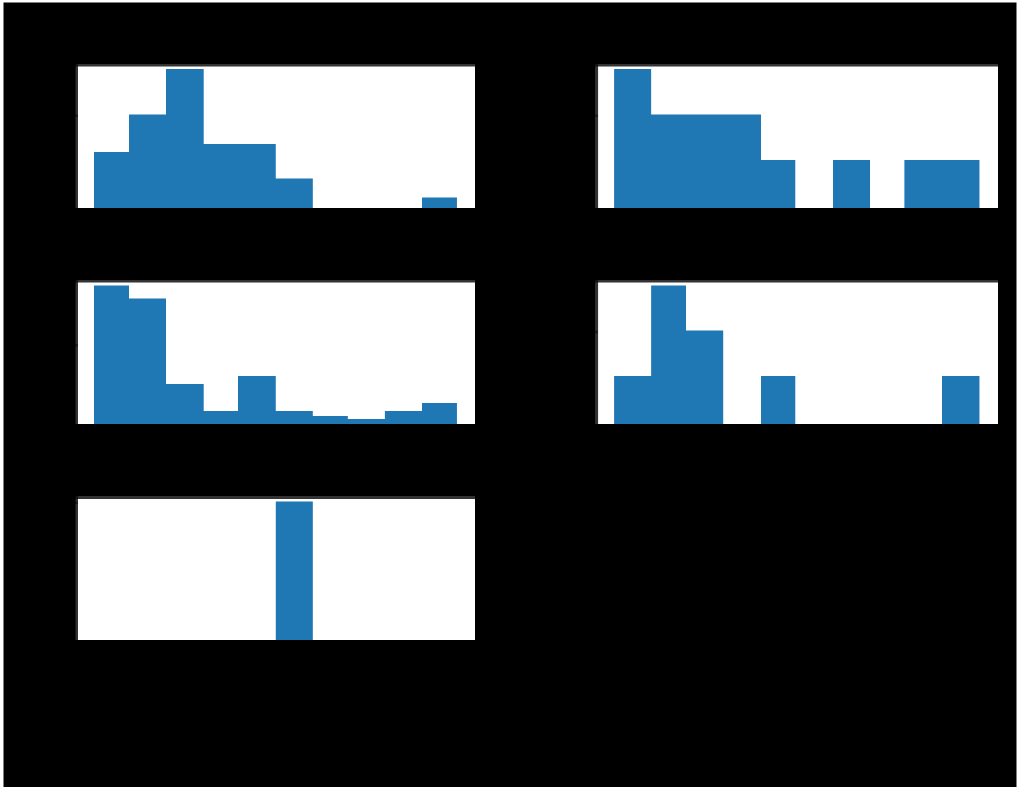
In [19]:

```
%%time

reviews.hist(column='length', by='role', bins=10)
```

```
Wall time: 344 ms
```

Out[19]:

```
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x0000022ADC11EBE0>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000022ADC16F2E8>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x0000022ADC19E8D0>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000022ADC1D0E80>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x0000022ADC20C470>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000022ADC240A20>]],
      dtype=object)
```



In [26]:

```
def split_into_tokens(review):


    #review = unicode(review, 'iso-8859-1')# in python 3 the default of str() previous
ly python2 as unicode() is utf-8

    return TextBlob(review).words
```

In [27]:

```
reviews.jobOrResumeDescription.head().apply(split_into_tokens)
```

Out[27]:

```
5      [PhD, or, MS, with, 3, years, post, MS, experi...
156    [A, data, scientist, with, 7, years, of, progr...
0      [Artificial, Intelligence, Machine, Learning, ...
99     [Senior, Data, Scientist, Kareo, Inc2, re, Irv...
187    [My, life, experience, has, been, in, assistan...
Name: jobOrResumeDescription, dtype: object
```

In [28]:

```
TextBlob("hello world, how is it going?").tags  # list of (word, POS) pairs
```

Out[28]:

```
[('hello', 'JJ'),
 ('world', 'NN'),
 ('how', 'WRB'),
 ('is', 'VBZ'),
 ('it', 'PRP'),
 ('going', 'VBG')]
```

In [29]:

```
import nltk

nltk.download('stopwords')
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     C:\Users\m\AppData\Roaming\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

Out[29]:

```
True
```

In [30]:

```
from nltk.corpus import stopwords


stop = stopwords.words('english')

stop = stop + [u'a',u'b',u'c',u'd',u'e',u'f',u'g',u'h',u'i',u'j',u'k',u'l',u'm',u'n',u
'o',u'p',u'q',u'r',u's',u't',u'v',u'w',u'x',u'y',u'z']
```

In [32]:

```
def split_into_lemmas(review):

    #review = unicode(review, 'iso-8859-1')

    review = review.lower()

    #review = unicode(review, 'utf8').lower()

    #review = str(review).lower()

    words = TextBlob(review).words

    # for each word, take its "base form" = lemma

    return [word.lemma for word in words if word not in stop]


reviews.jobOrResumeDescription.head().apply(split_into_lemmas)
```

Out[32]:

```
5      [phd, m, 3, year, post, m, experience, compute...
156    [data, scientist, 7, year, progressive, experi...
0      [artificial, intelligence, machine, learning, ...
99     [senior, data, scientist, kareo, inc2, irvine,...
187    [life, experience, assistant, manager, managem...
```

```
Name: jobOrResumeDescription, dtype: object
```

In [33]:

```
%%time

bow_transformer = CountVectorizer(analyzer=split_into_lemmas).fit(reviews['jobOrResume
Description'])

print(len(bow_transformer.vocabulary_))
```

```
10625
Wall time: 7.36 s
```

In [34]:

```
review4 = reviews['jobOrResumeDescription'][42]

print(review4)
```

```
At TGS, data is a core part of our business and our data focused software developers a
re among our most valued resources. This  is mission critical, so we?re  for an uncomm
only reliable professional who enjoys coding, ing with and analyzing data, and providi
ng support for production systems. In addition to programming and data analysis, this
is likely to involve interaction with external resources such as data providers, broke
rs, dealers, and software vendors.

Successful candis will have experience in a number of the following general areas:

    Programming: strong experience with Python, Java, SQL, and/or similar languages
    Large data sets: experience developing programs to parse, process, clean, organize
, and analyze large data sets
    Applications: experience designing, developing, and maintaining software applicati
ons
    Vendor interaction: ing with external resources to solve problems, acquire data, a
nd improve relationships.
    System : experience with scripting languages (Perl, Python, shell scripts, etc.),
and Unix-based operating systems (especially Linux)

Indeed Hire and TGS Management Company, LLC are ing together to find the best candi fo
r this .

By ing, you agree to be contacted by our agent, Indeed Hire, and receive ups via text
and phone about your application.

 Type: Full-time

Experience:

    Python, Java, SQL, and/or similar languages: 1 year ()
    designing, developing, and maintaining software applications: 1 year ()
    Large data sets: 2 years ()

 distance:

    Irvine, CA: Between 31 and 40 miles ()
```

In [35]:

```
bow4 = bow_transformer.transform([review4])

print(bow4)
```

```
  (0, 38)	2
  (0, 152)	1
  (0, 311)	1
  (0, 345)	1
  (0, 651)	1
  (0, 698)	1
  (0, 791)	1
  (0, 809)	1
  (0, 934)	1
  (0, 945)	1
  (0, 970)	1
  (0, 977)	1
  (0, 982)	2
  (0, 1136)	4
  (0, 1195)	1
  (0, 1548)	1
  (0, 1742)	1
  (0, 1785)	1
  (0, 1827)	1
  (0, 1873)	1
  (0, 1875)	1
  (0, 2137)	1
  (0, 2224)	1
  (0, 2302)	1
  (0, 2478)	1
  :	:
  (0, 8047)	1
  (0, 8149)	3
  (0, 8515)	1
  (0, 8518)	1
  (0, 8668)	3
  (0, 8718)	1
  (0, 8767)	2
  (0, 8878)	4
  (0, 8900)	1
  (0, 9017)	2
  (0, 9207)	1
  (0, 9265)	1
  (0, 9323)	1
  (0, 9389)	3
  (0, 9563)	1
  (0, 9576)	2
  (0, 9734)	1
  (0, 9940)	1
  (0, 9983)	1
  (0, 10035)	1
  (0, 10084)	1
  (0, 10180)	1
  (0, 10219)	2
  (0, 10251)	1
  (0, 10561)	3
```

In [36]:

```
%%time

reviews_bow = bow_transformer.transform(reviews['jobOrResumeDescription'])

print('sparse matrix shape:', reviews_bow.shape)

print('number of non-zeros:', reviews_bow.nnz)

print('sparsity: %.2f%%' % (100.0 * reviews_bow.nnz / (reviews_bow.shape[0] * reviews_bow.shape[1])))
```

```
sparse matrix shape: (201, 10625)
number of non-zeros: 61674
sparsity: 2.89%
Wall time: 6.97 s
```

In [37]:

```
# Split/splice into training ~ 80% and testing ~ 20%

reviews_bow_train = reviews_bow[:155]

reviews_bow_test = reviews_bow[155:]

reviews_sentiment_train = reviews['role'][:155]

reviews_sentiment_test = reviews['role'][155:]


print(reviews_bow_train.shape)

print(reviews_bow_test.shape)
```

```
(155, 10625)
(46, 10625)
```

In [38]:

```
%time review_sentiment = MultinomialNB().fit(reviews_bow_train, reviews_sentiment_trai
n)
```

```
Wall time: 438 ms
```

In [41]:

```
print('predicted:', review_sentiment.predict(bow4)[0])

print('expected:', reviews.role[42])
```

```
predicted: Data Analyst
expected: Developer
```

In [42]:

```
predictions = review_sentiment.predict(reviews_bow_test)

print(predictions)
```

```
['Data Analyst' 'Data Analyst' 'Data Analyst' 'Data Analyst'
 'Data Analyst' 'Data Scientist' 'Data Scientist' 'Data Analyst'
 'Data Scientist' 'Data Scientist' 'Data Scientist' 'Data Scientist'
 'Data Scientist' 'Data Analyst' 'Data Scientist' 'Data Scientist'
 'Data Scientist' 'Data Scientist' 'Data Analyst' 'Data Scientist'
 'Data Analyst' 'Data Analyst' 'Data Analyst' 'Data Scientist'
 'Data Scientist' 'Data Scientist' 'Data Scientist' 'Data Scientist'
 'Data Scientist' 'Data Analyst' 'Data Scientist' 'Data Analyst'
 'Data Analyst' 'Data Scientist' 'Data Scientist' 'Data Scientist'
 'Data Scientist' 'Data Analyst' 'Data Analyst' 'Data Analyst'
 'Data Scientist' 'Data Analyst' 'Data Scientist' 'Data Analyst'
 'Data Scientist' 'Data Scientist']
```

In [43]:

```
print('accuracy', accuracy_score(reviews_sentiment_test, predictions))
print('confusion matrix\n', confusion_matrix(reviews_sentiment_test, predictions))

print('(row=expected, col=predicted)')
```

```
accuracy 0.9347826086956522
confusion matrix
 [[18  0  0  0]
 [ 1  0  1  0]
 [ 0  0 25  0]
 [ 0  0  1  0]]
(row=expected, col=predicted)
```

In [44]:

```
print(classification_report(reviews_sentiment_test, predictions))

#The F1 score can be interpreted as a weighted average of the precision and recall,

#where an F1 score reaches its best value at 1 and worst score at 0.
```

```
                precision    recall  f1-score   support

  Data Analyst       0.95      1.00      0.97        18
 Data Engineer       0.00      0.00      0.00         2
Data Scientist       0.93      1.00      0.96        25
     Developer       0.00      0.00      0.00         1

      accuracy                           0.93        46
     macro avg       0.47      0.50      0.48        46
  weighted avg       0.87      0.93      0.90        46

c:\users\m\anaconda2\envs\python36\lib\site-packages\sklearn\metrics\classification.py
:1437: UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples.
  'precision', 'predicted', average, warn_for)
```

In [46]:

```
def predict_review(new_review):

    new_sample = bow_transformer.transform([new_review])

    print(new_review, '\nThe respective order new or pro probabilities:\n',np.around(r
eview_sentiment.predict_proba(new_sample), decimals=2),'\n')
```

In [51]:

```
reviews.role.unique()

#These will be alphabatized in the probabilities returned for the 5 categories.

#1-data analyst, 2-data engineer, 3-data scientist, 4-developer, 5-software engineer
```

Out[51]:

```
array(['Data Scientist', 'Developer', 'Data Analyst', 'Data Engineer',
       'Software Engineer'], dtype=object)
```

In [48]:

```
predict_review('R. programming. years. RDD. Python. Spark.')
predict_review('AWS. Azure. php. excel')


predict_review('access. microsoft. MS. office. sharepoint')

predict_review('analyst. tutoring. teaching. Assistant.')
```

```
R. programming. years. RDD. Python. Spark.
The respective order new or pro probabilities:
 [[0. 0. 1. 0. 0.]]

AWS. Azure. php. excel
The respective order new or pro probabilities:
 [[0. 0. 1. 0. 0.]]

access. microsoft. MS. office. sharepoint
The respective order new or pro probabilities:
 [[0.01 0.   0.99 0.   0.  ]]

analyst. tutoring. teaching. Assistant.
The respective order new or pro probabilities:
 [[0.02 0.01 0.96 0.   0.  ]]
```

Most of the above are Data Scientists, but there are some percentage probabilties of being a job posting or resume for data analyst and data engineer.

In [ ]: