Test Assignment - Imanul jihad

August 18, 2021

1 Problem statement

give personalized recommendations to student what to study next and what video to watch each time student completing a test.

given historical data of student performances on test and you're asked to predict probability of correct answer for the next question.

1.1 Task

1. Create an Exploratory data analysis (EDA) and create a model to predict probability of is_correct in test.csv file given the training data.
2. Briefly Explain your thought process and approach

2 Business Problem

from task above we can conclude that we want to predict probability of correct answer for the next question. From business case and from dataset we can create a supervised learning with classification method.

in supervised learning we can create several methods and find the best method that gives the best success matrix. after that we can train that model with hypermeter tunning to get best hyperparameter set so we can improve our model.

success criteria that request from this task is area under the ROC curve between the predicted probability and the observed target.

the expected output is a submission.csv file with the same format as submission_example.csv file.

the dataset come from the task so we can assume that the data was clean and easy to access.

3 Library

[28]:
```
import numpy as np
import pandas as pd
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split
```

[29]:
```
%load_ext autoreload
%autoreload 2

import sys
sys.path.append(f'E:\gitlab\custom-script\script')
from ursar import describe,visual,tunning,fe, model, scoring, feature_importance

%reload_ext autoreload
```

```
The autoreload extension is already loaded. To reload it, use:
  %reload_ext autoreload
```

4 Dataset

4.1 Files

[173]:
```
train = pd.read_csv('train.csv')
train.head()
```

[173]:
```
   user_id  session_id  session_no       topic   sub_topic  learning_node  \
0  2348875  5473538500         1.0  1064573894  6164056362     1683819444
1  2348875  5473538500         1.0  1064573894  6164056362     1683819444
2  2348875  3206055652         2.0  1064573894  6164056362     1683819444
3  2766044  9605991415         1.0  4794286044  6471306273     3791168789
4  2766044  7255460452         2.0  4794286044  2158335016     7856645946

   question_id  question_type  session_question_no  learning_node_question_no  \
0   2226271822  Single choice                    1                          1
1   2226271822  Single choice                    2                          2
2   5592568637  Single choice                    1                          1
3   1243898418  Single choice                    1                          1
4   4732798598  Single choice                    1                          1

  question_difficulty  question_number_of_choice  \
0              medium                          4
1              medium                          4
2              medium                          4
3              medium                          4
4              medium                          4

   question_number_of_correct_choice  question_number_of_correct_selected  \
0                                  1                                    0
1                                  1                                    0
2                                  1                                    1
3                                  1                                    1
4                                  1                                    1
```

```
   question_number_of_wrong_selected  ms_first_response  is_correct  row_id
0                                  1               18.0         0.0       0
1                                  1               12.0         0.0       1
2                                  0               11.0         1.0       2
3                                  0               47.0         1.0       3
4                                  0                7.0         1.0       4
```

[174]:
```
test = pd.read_csv('test.csv')
test.head()
```

[174]:
```
   user_id  session_id  session_no       topic   sub_topic  learning_node  \
0  2348875  3206055652         2.0  1064573894  6164056362     1683819444
1  2766044  2972889287        11.0  1737274108  6197171301     8772005155
2  3604867  8630265714         4.0  2624511878  5665086549     1064446677
3  4061807  7315912009        10.0   147927464  5665086549     7469873307
4  5713467  7344767708         3.0   253258722  2774427363     3261917054

   question_id question_type  session_question_no  learning_node_question_no  \
0   2226271822 Single choice                    2                          2
1   8350981375 Single choice                    6                          2
2   7911407965 Single choice                    8                          2
3   2368078655 Single choice                    7                          1
4   6616709393 Single choice                    9                          3

  question_difficulty  question_number_of_choice  \
0              medium                          4
1              medium                          4
2                 NaN                          4
3                 NaN                          4
4              medium                          4

   question_number_of_correct_choice  row_id
0                                  1       0
1                                  1       1
2                                  1       2
3                                  1       3
4                                  1       4
```

5 Data understanding

5.1 Dataset info

[6]:
```
describe.describe_data(train)
```

```
'table size 286886 x 18'

Dataframe has 18 columns.
There are 1 columns that have missing values.
```

[6]:

```
                             column_names Data Type  Missing Values  % missing  \
0                                 user_id     int64               0       0.00
1                              session_id     int64               0       0.00
2                              session_no   float64               0       0.00
3                                   topic     int64               0       0.00
4                               sub_topic     int64               0       0.00
5                           learning_node     int64               0       0.00
6                             question_id     int64               0       0.00
7                           question_type    object               0       0.00
8                     session_question_no     int64               0       0.00
9               learning_node_question_no     int64               0       0.00
10                    question_difficulty    object          166513      58.04
11              question_number_of_choice     int64               0       0.00
12      question_number_of_correct_choice     int64               0       0.00
13    question_number_of_correct_selected     int64               0       0.00
14      question_number_of_wrong_selected     int64               0       0.00
15                      ms_first_response   float64               0       0.00
16                             is_correct   float64               0       0.00
17                                 row_id     int64               0       0.00

   low Value    Hi Value stddev Value    unique
0    2348875  9997990646   2875513775    7000.0
1     424084  9999846794   2878680609   47222.0
2          1        1311          164    1311.0
3    1952256  9999385357   3013026089    1639.0
4    1314703  9993728634   1932006810    2265.0
5    4985900  9999782161   2889600192   12093.0
6     179554  9999972554   2921249861   30653.0
7          0           0            0       3.0
8          1          44            4      44.0
9          1          32            1      32.0
10         0           0            0       4.0
11         2           6            1       5.0
12         1           1            0       1.0
13         0           1            0       2.0
14         0           3            0       4.0
15         1     2171996        11812    8806.0
16         0           1            0       2.0
17         0      286885        82817  286886.0
```

[7]:

```
describe.describe_data(test)
```

```
'table size 7000 x 14'
```

```
Dataframe has 14 columns.
There are 1 columns that have missing values.
```

[7]:

	column_names	Data Type	Missing Values	% missing	\
0	user_id	int64	0	0.0	
1	session_id	int64	0	0.0	
2	session_no	float64	0	0.0	
3	topic	int64	0	0.0	
4	sub_topic	int64	0	0.0	
5	learning_node	int64	0	0.0	
6	question_id	int64	0	0.0	
7	question_type	object	0	0.0	
8	session_question_no	int64	0	0.0	
9	learning_node_question_no	int64	0	0.0	
10	question_difficulty	object	2877	41.1	
11	question_number_of_choice	int64	0	0.0	
12	question_number_of_correct_choice	int64	0	0.0	
13	row_id	int64	0	0.0	

	low Value	Hi Value	stddev Value	unique
0	2348875	9997990646	2880925984	7000.0
1	1104080	9999097475	2878866406	7000.0
2	1	1311	30	116.0
3	1952256	9999385357	3101228743	1132.0
4	10204249	9974498793	2262454745	1229.0
5	9253933	9998905485	2926192694	3591.0
6	338236	9999972554	2950053992	4829.0
7	0	0	0	2.0
8	1	45	5	27.0
9	1	33	1	9.0
10	0	0	0	4.0
11	2	5	1	4.0
12	1	1	0	1.0
13	0	6999	2021	7000.0

5.2 Define data

from the examples above we can conclude:

1. unit analysis is `user ID`
2. features that we want to analyst and have high probability to become input for our model later are:
   a. session_no
   b. topic
   c. sub_topic
   d. learning_node
   e. question_id
   f. question_type

g. session_question_no

h. learning_node_question_no

i. question_difficulty

j. question_number_of_choice

3. these are features that just a unique ID, haven't impact to our data or only have single value for entire dataset, there are:

   a. session_id

   b. row_id

   c. question_number_of_correct_choice

4. These are features just exist at training data and didn,t exist at testing data so these features can't be include in train data

   a. ms_first_response

   b. question_number_of_wrong_selected

   c. question_number_of_correct_selected

5. The label data is `is_correct` with binary unique value, so we want to create model of binary classification supervised learning. `1 if correct and 0 otherwise`

from selected features we can seperate them to numerical and categorical data so we can easy to planning next step:

from dataset info previously we got all munerical data from training dataset for all features with numeric value and just single categorical data. But if we look deeper for every feature we can conclude some features are better to be categorical rather than numerical such as:

a. topic

b. sub_topic

c. learning_node

d. question_id

because at these features number just a separating value from each other number and have not a meaningful order. so we plan to change these features data type to categorical.

There is a note here, because the range of these features is to high for academic purpose (i.e. 1132 topics in academic is huge number of topic) so we can assume these features are random value.

however, if these features will become categorical, we found out that in test dataset there are rows that have unlist value in these 4 features at training dataset (you can see detail at `unlist value from test dataset compare to train dataset`). This condition is kinda bad because these 4 features are quite related to business case that we want to solve (i.e. some topics / sub topics are difficult for some students and will give enough weight for some students to give a correct answer).

because of that, we will propose to give a weight of evidence encoding for these features. this kind of encoding will measures the "strength" of a grouping technique to separate true and false (from label data) and also this method create binning process to create a few categories. binning process is good for these features because although these features have not a meaningful order, but in some cases (i.e. topic about something) the similiar topic always close for each other, so we can assume binning process is fine for the dataset. another argument is all the unlist data still in the range of these features at training data look at `comparing unlist value from training data to test data, did the unlist data still in the range of training data?` so binning process can work fine with our dataset.

one of the features has high missing value, this feature `question_difficulty` has 58% missing value from training dataset and 41% from test dataset. there are many ways to handle this feature:

1. we can remove it from all dataset
2. we can filling it with random value from known range value (but this method will lead to huge variance because we lost almost 50% confident for this feature and because this feature is categorical, random filling will lead to miss interpretation)
3. create new value for missing value (this method may be the best solution expecially for categorical, and we can create OHE for this feature and create 1 column to give value where missing value occur)

5.3 Unlist value from test dataset compare to train dataset

[8]:
```
test[~test['topic'].isin(train['topic'])]
```

[8]:
```
         user_id  session_id  session_no       topic   sub_topic  \
2251  3172304218  6089320365        10.0  7965792980  6028671853
3793  5379331392  1595179603         7.0  4231385167  5665086549
5383  7634315972  8227487092         2.0  1154474360  3007338813
5967  8475903903  8888589494         3.0  6137286633  2855158986
6113  8697871451  1963868665         2.0  9379519776  1698816542

      learning_node  question_id  question_type  session_question_no  \
2251     4690301528   3405472432  Single choice                    1
3793     6395264132   5278745365  Single choice                    1
5383     8081729241   8569812195  Single choice                    1
5967     9131938417   5549837575  Single choice                    1
6113     4449847444   5959431743  Single choice                    1

      learning_node_question_no question_difficulty  \
2251                          1              medium
3793                          1                 NaN
5383                          1              medium
5967                          1              medium
6113                          1              medium

      question_number_of_choice  question_number_of_correct_choice  row_id
2251                          4                                  1    2251
3793                          5                                  1    3793
5383                          5                                  1    5383
```

```
5967                          4                                  1    5967
6113                          4                                  1    6113
```

[9]:
```
test[~test['sub_topic'].isin(train['sub_topic'])]
```

[9]:
```
         user_id  session_id  session_no       topic   sub_topic  \
16      31096286  4935449409        21.0  7698081065  8494431232
651    949706212  5097570453         1.0  4444322909   221225755
1224  1712017337  1977901645         1.0  1957384178  2877607674
4918  6993987802  9158250163         1.0  2904461013  2195376043

      learning_node  question_id  question_type  session_question_no  \
16       7531642834   7395238231  Single choice                    1
651      8375959185    930873949  Single choice                    5
1224     5379146646   9944632419  Single choice                    5
4918     3757499870   1898943844  Single choice                    5

      learning_node_question_no question_difficulty  \
16                            1              medium
651                           1              medium
1224                          1              medium
4918                          1              medium

      question_number_of_choice  question_number_of_correct_choice  row_id
16                            5                                  1      16
651                           5                                  1     651
1224                          5                                  1    1224
4918                          5                                  1    4918
```

[10]:
```
test[~test['learning_node'].isin(train['learning_node'])]
```

[10]:
```
         user_id  session_id  session_no       topic   sub_topic  \
124    175768950  6068179256         1.0  7782355726  5665086549
141    199796999  4003506723         2.0  2373689175  1808541640
195    275884425  9299936660         1.0  9571703988  4248113749
299    433567593   894883782         1.0  7355707374  5665086549
375    528873677  6458146634        21.0  9813543922  3845158305
…            …           …           …           …           …
6538  9336481191  3982168154         1.0  7368974261  7539953578
6801  9704168779  4764572647        16.0  9072251744  6028671853
6837  9771177228  8802502204         2.0   701160701  9662448319
6899  9860654599  2290296405         1.0   227751039  7244770119
6992  9985081626  1960503530         1.0  5970464404  8363968718

      learning_node  question_id  question_type  session_question_no  \
124      9456016016   6326974992  Single choice                    6
141      4271422668   1366995099  Single choice                    7
```

```
195    8071390837  6946342972  Single choice                 9
299    6788581348  1667422462  Single choice                 2
375    9354664726  3678458087  Single choice                 8
…          …           …            …               …
6538   9403995534  3324709555  Single choice                 5
6801   9137050916   700270568  Single choice                 8
6837   1654827980  7702943795  Single choice                 6
6899   6109881556  3963782537  Single choice                13
6992   7359359464  5953566422  Single choice                 4

      learning_node_question_no question_difficulty  \
124                           1                 NaN
141                           1              medium
195                           1              medium
299                           1                 NaN
375                           1              medium
…                           …                 …
6538                          1              medium
6801                          1              medium
6837                          1              medium
6899                          1              medium
6992                          1              medium

      question_number_of_choice  question_number_of_correct_choice  row_id
124                           5                                  1     124
141                           5                                  1     141
195                           5                                  1     195
299                           5                                  1     299
375                           5                                  1     375
…                           …                                …     …
6538                          5                                  1    6538
6801                          4                                  1    6801
6837                          5                                  1    6837
6899                          5                                  1    6899
6992                          5                                  1    6992

[76 rows x 14 columns]
```

[11]:
```
test[~test['question_id'].isin(train['question_id'])]
```

[11]:
```
        user_id  session_id  session_no       topic   sub_topic  \
34     53501860  9789010669         1.0  3070768229  9710050288
40     65410125  6941023428         9.0  5481091354  2230285223
48     79246003  1522584804         1.0  4524197618  1906871219
70    102548374  3919301125         1.0  7207679382  6521270055
85    122624186  4641634284         1.0   144815081  3763689638
…           …           …         …         …           …
```

```
6981  9973419602  9466302379         1.0  9972533064  8607737295
6986  9979680855  6747643499         2.0  8640910518  4444442673
6988  9981754407  5128024958         1.0  1676475660  1345997982
6992  9985081626  1960503530         1.0  5970464404  8363968718
6997  9989505176  6679766557         6.0  1937708227  2177007574

      learning_node  question_id  question_type  session_question_no  \
34       6965979883   4072300635  Single choice                    6
40       2465188488   5933428626  Single choice                    2
48       8260971862   3946876502  Single choice                   14
70       7646070404   6452304698  Single choice                    3
85       8419046807   9095763210  Single choice                    2
…                 …            …            …                    …
6981     7677200932   3837184927  Single choice                    2
6986     5170944250   2336495034  Single choice                    1
6988     7996123806   2100463006  Single choice                    7
6992     7359359464   5953566422  Single choice                    4
6997     3886489050   6675622814  Single choice                   14

      learning_node_question_no question_difficulty  \
34                            3              medium
40                            2              medium
48                            2              medium
70                            3              medium
85                            2              medium
…                           …                 …
6981                          2              medium
6986                          1              medium
6988                          1              medium
6992                          1              medium
6997                          2              medium

      question_number_of_choice  question_number_of_correct_choice  row_id
34                            4                                  1      34
40                            4                                  1      40
48                            5                                  1      48
70                            5                                  1      70
85                            5                                  1      85
…                           …                                …      …
6981                          4                                  1    6981
6986                          4                                  1    6986
6988                          4                                  1    6988
6992                          5                                  1    6992
6997                          5                                  1    6997

[364 rows x 14 columns]
```

5.3.1 comparing unlist value from training data to test data, did the unlist data still in the range of training data?

[12]:
```
test[test['topic'] > np.max(train['topic'])]
```

[12]:
```
Empty DataFrame
Columns: [user_id, session_id, session_no, topic, sub_topic, learning_node,
question_id, question_type, session_question_no, learning_node_question_no,
question_difficulty, question_number_of_choice,
question_number_of_correct_choice, row_id]
Index: []
```

[13]:
```
test[test['sub_topic'] > np.max(train['sub_topic'])]
```

[13]:
```
Empty DataFrame
Columns: [user_id, session_id, session_no, topic, sub_topic, learning_node,
question_id, question_type, session_question_no, learning_node_question_no,
question_difficulty, question_number_of_choice,
question_number_of_correct_choice, row_id]
Index: []
```

[14]:
```
test[test['learning_node'] > np.max(train['learning_node'])]
```

[14]:
```
Empty DataFrame
Columns: [user_id, session_id, session_no, topic, sub_topic, learning_node,
question_id, question_type, session_question_no, learning_node_question_no,
question_difficulty, question_number_of_choice,
question_number_of_correct_choice, row_id]
Index: []
```

[15]:
```
test[test['question_id'] > np.max(train['question_id'])]
```

[15]:
```
Empty DataFrame
Columns: [user_id, session_id, session_no, topic, sub_topic, learning_node,
question_id, question_type, session_question_no, learning_node_question_no,
question_difficulty, question_number_of_choice,
question_number_of_correct_choice, row_id]
Index: []
```

6 EDA

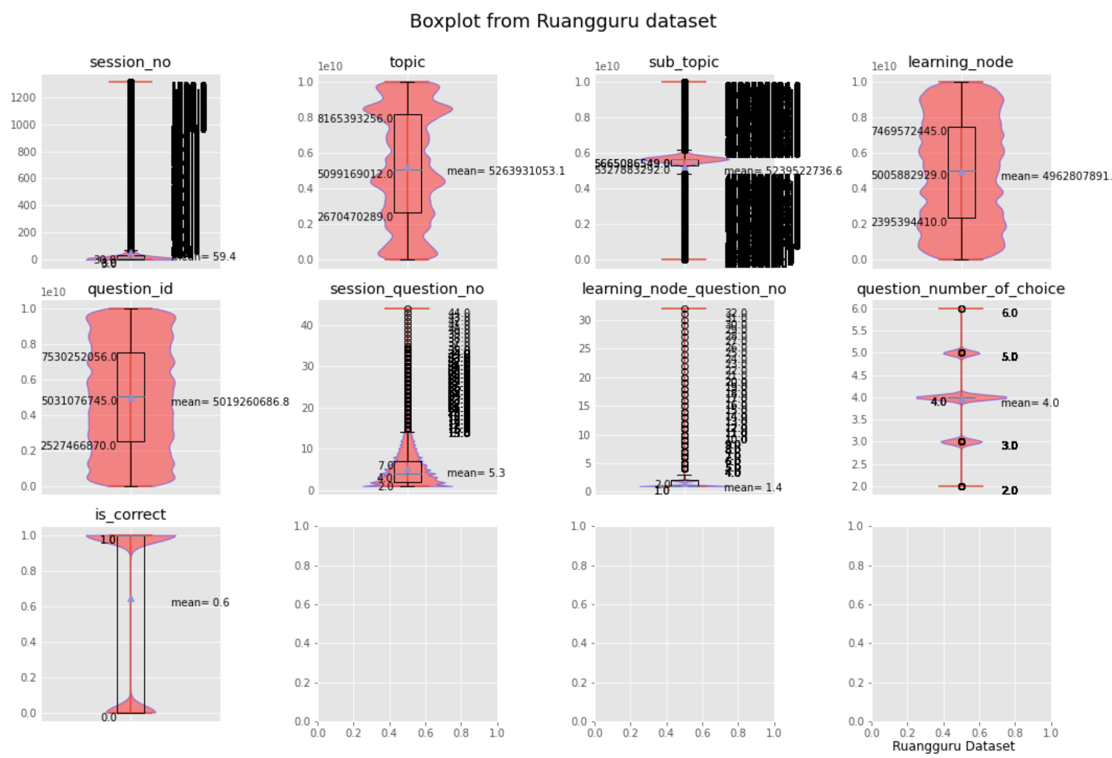
[16]:
```
train.columns
```

[16]:
```
Index(['user_id', 'session_id', 'session_no', 'topic', 'sub_topic',
       'learning_node', 'question_id', 'question_type', 'session_question_no',
       'learning_node_question_no', 'question_difficulty',
       'question_number_of_choice', 'question_number_of_correct_choice',
       'question_number_of_correct_selected',
```

```
 'question_number_of_wrong_selected', 'ms_first_response', 'is_correct',
 'row_id'],
dtype='object')
```

[52]:
```
col = ['session_no', 'topic', 'sub_topic',
       'learning_node', 'question_id','question_type', 'session_question_no',
       'learning_node_question_no','question_difficulty',
       'question_number_of_choice',
       'is_correct']
```

[18]:
```
visual.boxplot(train,col,row_col=(3,4)
                 ,title="Ruangguru",footnote='Ruangguru Dataset')
```

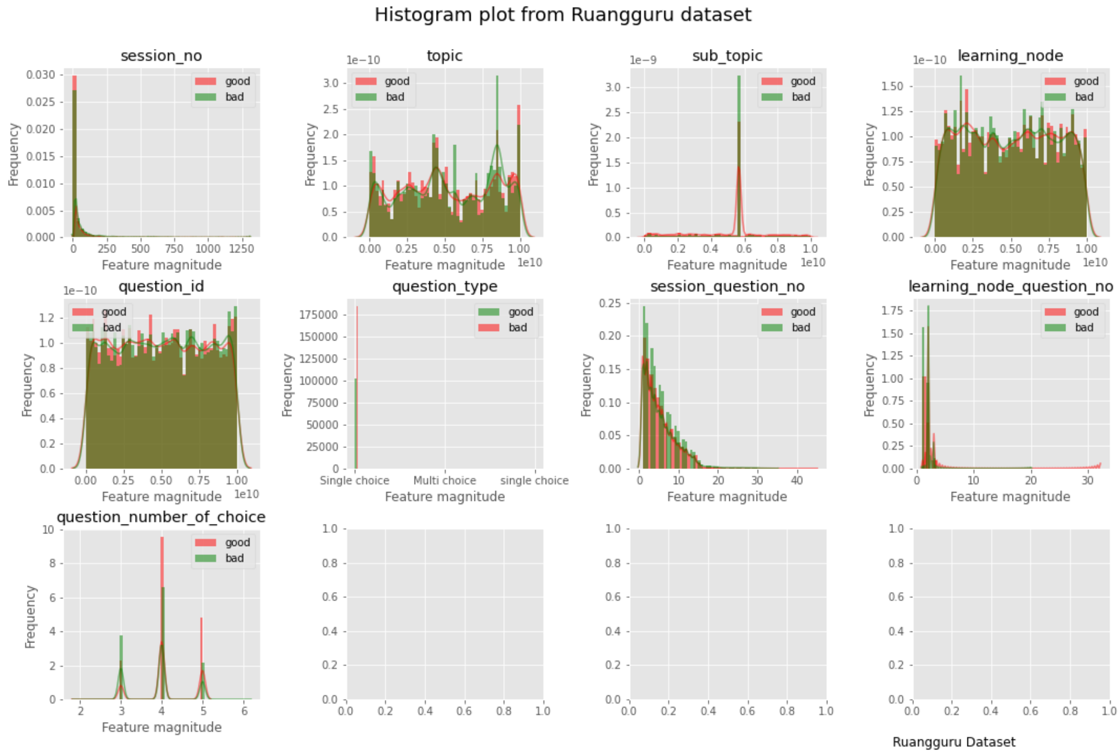


from boxplot we can conclude that:

1. we have high outlier for `session_no`, `learning_node_question_no`, `session_question_no` and one feature with outlier for both side at `sub_topic`
2. 3 features with good distribution (as the box plot shown) are `topic`, `learning_node` and `question_id`
3. `question_number_of choice` has categorical data type with high unique count at number 4

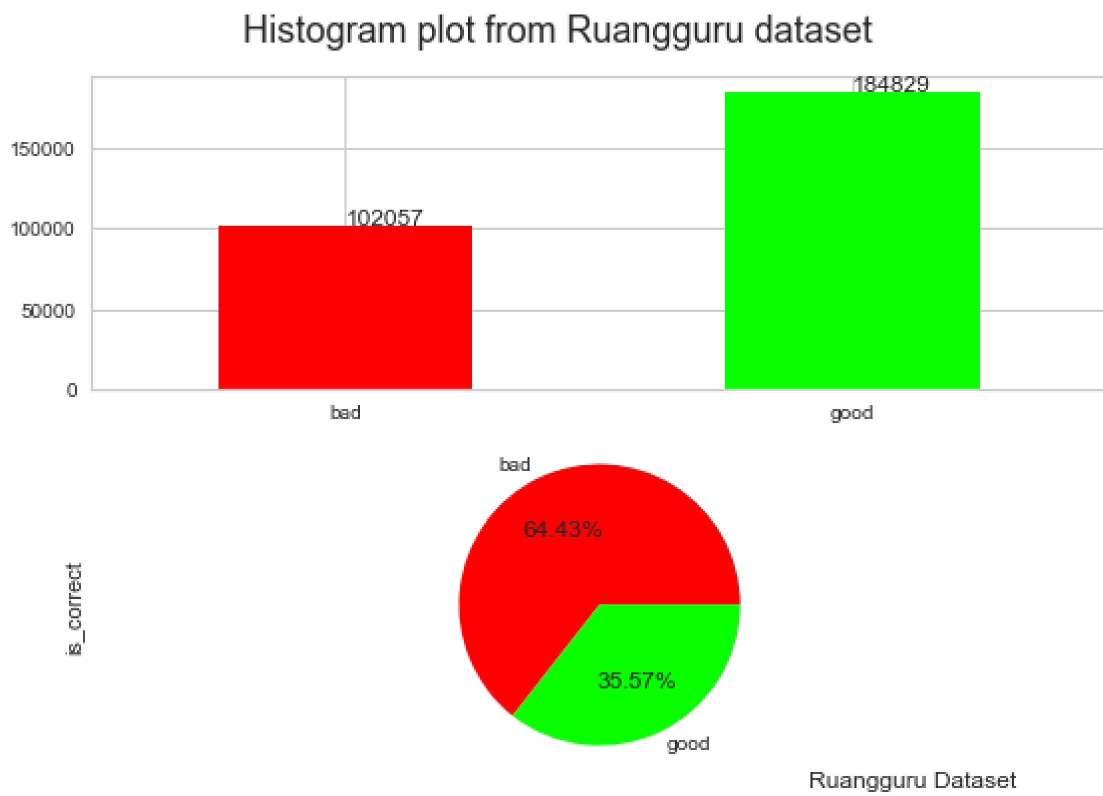
[25]:
```
visual.histogram_columns(train[col],'is_correct',label=["good", "bad"],
                           row_col=(3,4),bins=50,title="Ruangguru",
```

```
                                footnote='Ruangguru Dataset')
```



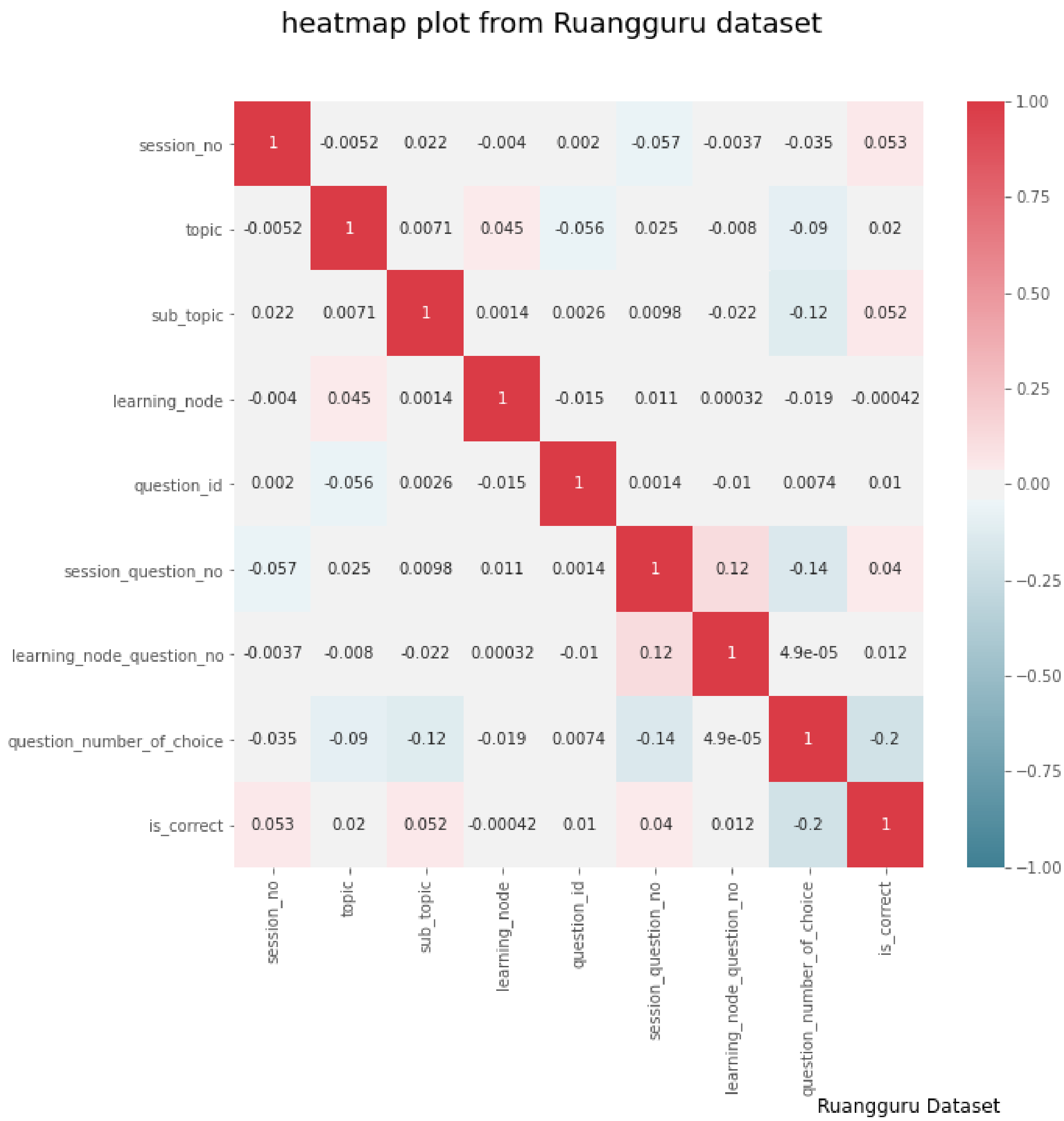
from plot above we can find that `sub_topic`, `question_number_of_choice` and `question_type` have quite distince value for each classes at label.

[56]:
```
visual.bar_and_pie_plot(train,'is_correct',label=["bad","good"],
                        title="Ruangguru", footnote='Ruangguru Dataset')
```



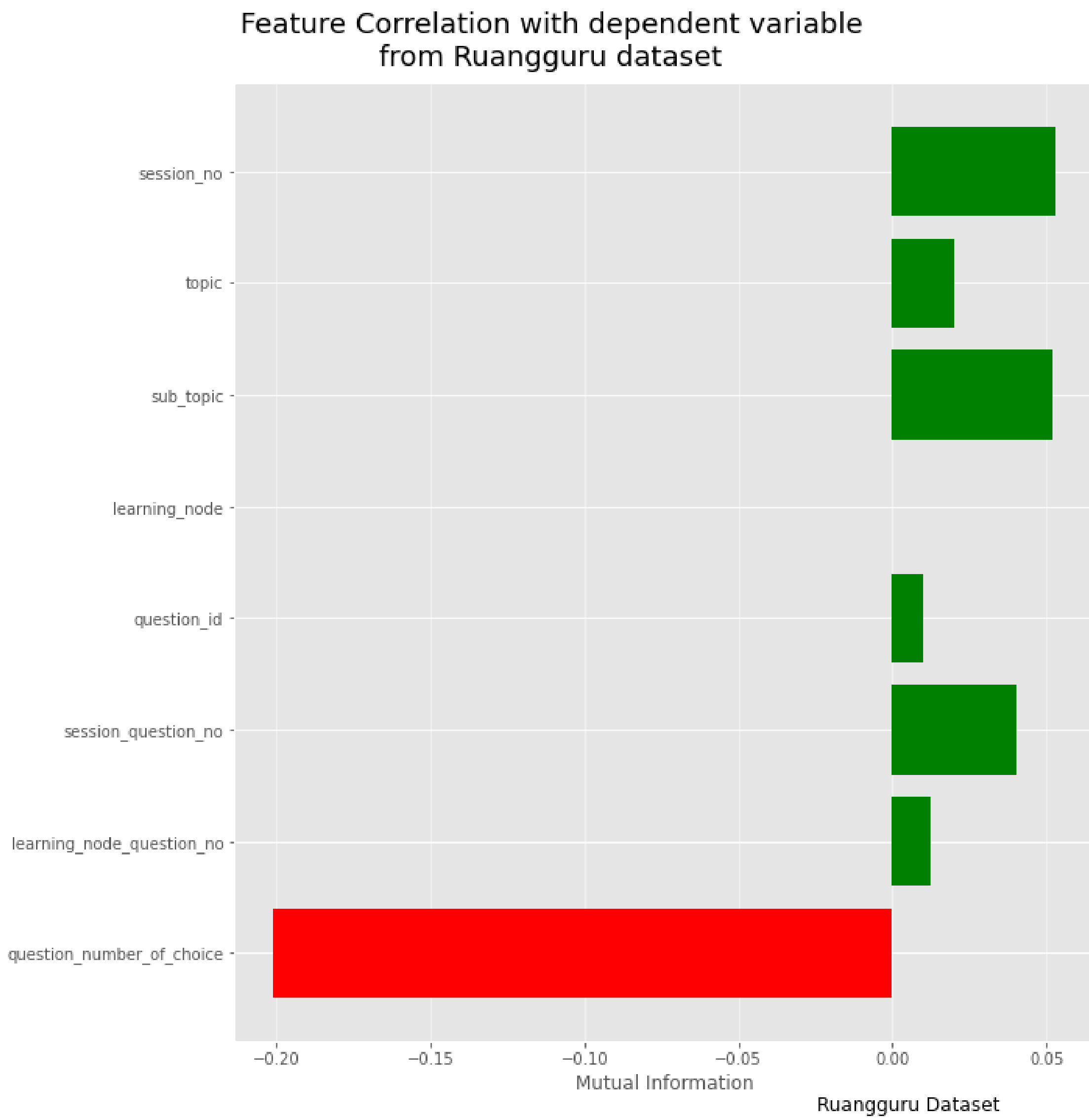
from our dataset we found that we have imbalance dataset with bad(0):good(1) ratio about 64:36. so, we can perpose to add imbalance handleing process such as smote, Nearmiss, or under-sampling etc.

[39]:
```
visual.heatmap_corr(train[col],"pearson",
                    title="Ruangguru", footnote='Ruangguru Dataset')
```



from plot above we found that there is no high corelation between features (more than 0.5). this is good start because be don't need to change those features except all the steps that we have plan before.

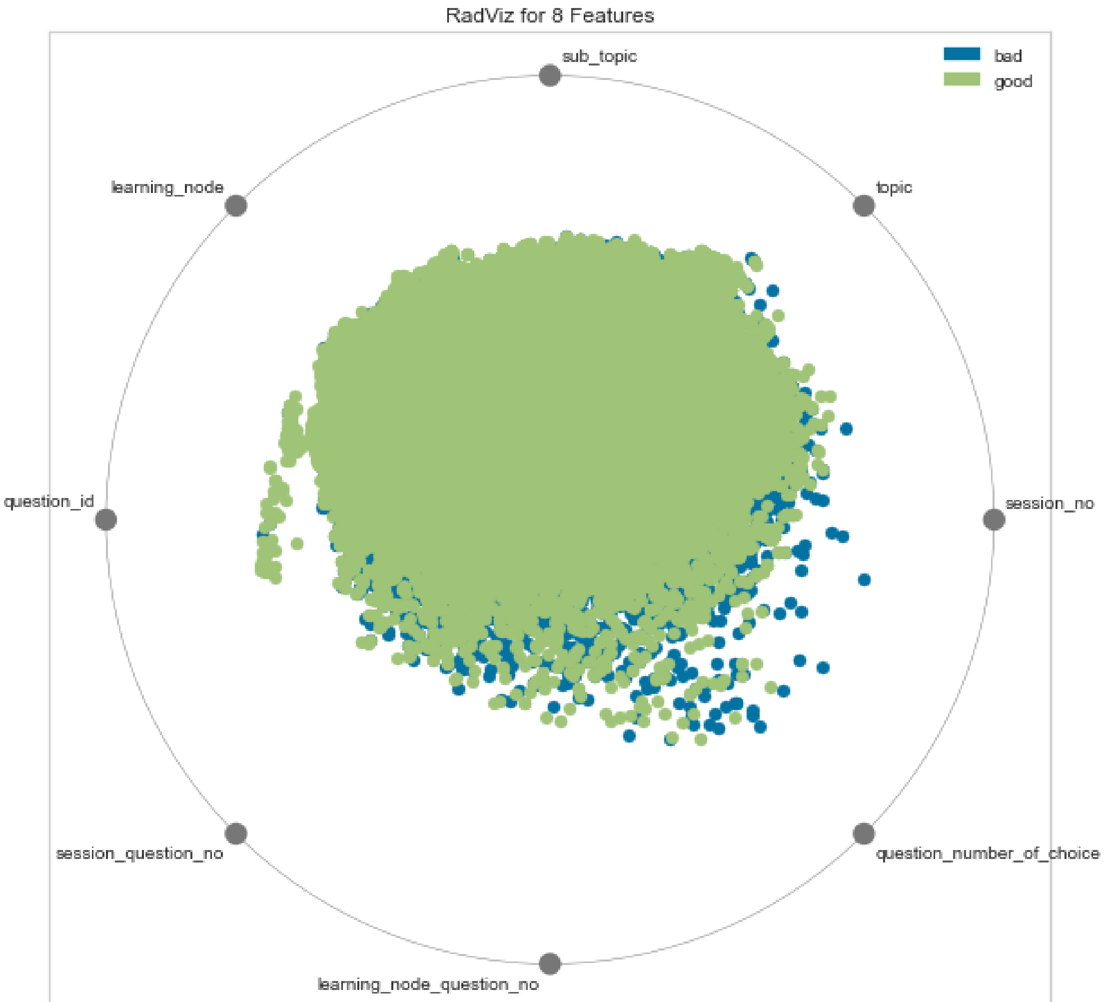
[41]:
```
visual.label_corr(train[col],'is_correct',type_coor="pearson",
                  title="Ruangguru", footnote='Ruangguru Dataset')
```



as we can see we got high corelation at `question_number_of_choice` to label data. we will see this plot again after we have doing some feature engineering to see changing value from this plot.

[57]:
```
col = ['session_no', 'topic', 'sub_topic',
       'learning_node', 'question_id', 'session_question_no',
       'learning_node_question_no',
       'question_number_of_choice',
       'is_correct']
```

[58]:
```
visual.radviz(train[col],'is_correct',labels=["bad","good"])
```



from this plot we can see that we create multivariate data visualization to see how well separability between classes compare with features. as we can see we almost can't to detect separability between classes and maybe it lead to low opportunity to learn from the feature set for prediction.

7 Feature Engineering

7.1 Selected Columns

[175]:
```
col = ['session_no', 'topic', 'sub_topic',
        'learning_node', 'question_id',"question_type", 'session_question_no',
        'learning_node_question_no','question_difficulty',
        'question_number_of_choice','is_correct']
```

[176]:
```
train = train[col]
```

[177]:
```
describe.describe_data(train)
```

```
'table size 286886 x 11'

Dataframe has 11 columns.
There are 1 columns that have missing values.
```

[177]:

```
                 column_names Data Type  Missing Values  % missing low Value  \
0                  session_no   float64               0       0.00         1
1                       topic     int64               0       0.00   1952256
2                   sub_topic     int64               0       0.00   1314703
3               learning_node     int64               0       0.00   4985900
4                 question_id     int64               0       0.00    179554
5               question_type    object               0       0.00         0
6         session_question_no     int64               0       0.00         1
7   learning_node_question_no     int64               0       0.00         1
8         question_difficulty    object          166513      58.04         0
9   question_number_of_choice     int64               0       0.00         2
10                 is_correct   float64               0       0.00         0

      Hi Value stddev Value   unique
0         1311          164   1311.0
1   9999385357   3013026089   1639.0
2   9993728634   1932006810   2265.0
3   9999782161   2889600192  12093.0
4   9999972554   2921249861  30653.0
5            0            0      3.0
6           44            4     44.0
7           32            1     32.0
8            0            0      4.0
9            6            1      5.0
10           1            0      2.0
```

7.2 WoE Transform

[178]:

```python
train,topic_res = fe.encode(train,'topic','woe',
                            label_col='is_correct',label=['bad','good'])
```

[179]:

```python
train,sub_topic_res = fe.encode(train,'sub_topic','woe',
                            label_col='is_correct',label=['bad','good'])
```

[180]:

```python
train,learning_node_res = fe.encode(train,'learning_node','woe',
                            label_col='is_correct',label=['bad','good'])
```

[181]:

```python
train,question_id_res = fe.encode(train,'question_id','woe',
                            label_col='is_correct',label=['bad','good'])
```

[117]:

```python
train = train.drop(columns =␣
↪["topic",'sub_topic','learning_node','question_id'])
```

[118]:
```
describe.describe_data(train)
```

```
'table size 286886 x 11'

Dataframe has 11 columns.
There are 1 columns that have missing values.
```

[118]:
```
                  column_names Data Type  Missing Values  % missing low Value  \
0                   session_no   float64               0       0.00         1
1                question_type    object               0       0.00         0
2          session_question_no     int64               0       0.00         1
3    learning_node_question_no     int64               0       0.00         1
4          question_difficulty    object          166513      58.04         0
5    question_number_of_choice     int64               0       0.00         2
6                   is_correct   float64               0       0.00         0
7              topic_WoE_Encode   float64               0       0.00     -9999
8          sub_topic_WoE_Encode   float64               0       0.00     -9999
9     learning_node_WoE_Encode   float64               0       0.00     -9999
10      question_id_WoE_Encode   float64               0       0.00     -9999

   Hi Value stddev Value  unique
0      1311          164  1311.0
1         0            0     3.0
2        44            4    44.0
3        32            1    32.0
4         0            0     4.0
5         6            1     5.0
6         1            0     2.0
7        14          232  1019.0
8        14          391   807.0
9        14         1178  1369.0
10       14         2145  1125.0
```

7.3 Encode Transform

7.3.1 question_difficulty

[49]:
```
train['question_difficulty'] = train['question_difficulty'].replace(np.nan,␣
↪"None")
```

[50]:
```
train['question_difficulty'].unique()
```

[50]:
```
array(['medium', 'None', 'easy', 'hard', 'hots'], dtype=object)
```

[51]:
```
train = fe.encode(train,['question_difficulty'],"ohe")
```

[52]:
```
train
```

[52]:

```
        session_no  question_type  session_question_no  \
0              1.0  Single choice                    1
1              1.0  Single choice                    2
2              2.0  Single choice                    1
3              1.0  Single choice                    1
4              2.0  Single choice                    1
…              …              …                    …
286881        56.0  Single choice                    9
286882        56.0  Single choice                   10
286883        57.0  Single choice                    1
286884        57.0  Single choice                    2
286885        57.0  Single choice                    3

        learning_node_question_no  question_number_of_choice  is_correct  \
0                               1                          4         0.0
1                               2                          4         0.0
2                               1                          4         1.0
3                               1                          4         1.0
4                               1                          4         1.0
…                               …                          …          …
286881                          1                          3         1.0
286882                          2                          3         1.0
286883                          1                          3         1.0
286884                          1                          3         1.0
286885                          1                          3         1.0

        topic_WoE_Encode  sub_topic_WoE_Encode  learning_node_WoE_Encode  \
0               1.284016              1.351203                  1.351203
1               1.284016              1.351203                  1.351203
2               1.284016              1.351203                  1.351203
3               0.285275              0.583146                 -0.154151
4               0.285275              0.729961                  0.887303
…                    …                    …                        …
286881          1.969312              0.947891                  1.951845
286882          1.969312              0.947891                  1.951845
286883          1.809824              0.947891                  4.718499
286884          1.809824              0.947891                  3.601868
286885          1.809824              0.947891                  1.598856

        question_id_WoE_Encode  question_difficulty_None  \
0                     1.306252                         0
1                     1.306252                         0
2                     1.386294                         0
3                     0.405465                         0
4                    13.815511                         0
…                          …                         …
286881                2.622436                         1
```

```
286882              2.622436                         1
286883              4.718499                         1
286884              3.601868                         1
286885              1.598856                         1

        question_difficulty_easy  question_difficulty_hard  \
0                              0                         0
1                              0                         0
2                              0                         0
3                              0                         0
4                              0                         0
…                            …                        …
286881                         0                         0
286882                         0                         0
286883                         0                         0
286884                         0                         0
286885                         0                         0

        question_difficulty_hots  question_difficulty_medium
0                              0                           1
1                              0                           1
2                              0                           1
3                              0                           1
4                              0                           1
…                            …                          …
286881                         0                           0
286882                         0                           0
286883                         0                           0
286884                         0                           0
286885                         0                           0

[286886 rows x 15 columns]
```

7.3.2 question_type

[53]:
```
train['question_type'].unique()
```

[53]:
```
array(['Single choice', 'Multi choice', 'single choice'], dtype=object)
```

[54]:
```
train['question_type'] = train['question_type'].replace("single choice",␣
 ↪"Single choice")
```

[55]:
```
train['question_type'].unique()
```

[55]:
```
array(['Single choice', 'Multi choice'], dtype=object)
```

[56]:
```
key = [{0.0:"Single choice", 1.0:'Multi choice'}]
```

[57]:
```python
train,dicts = fe.mapping(train,['question_type'],"def",key)
```

[58]:
```python
train
```

[58]:
```
        session_no  question_type  session_question_no  \
0              1.0            0.0                    1
1              1.0            0.0                    2
2              2.0            0.0                    1
3              1.0            0.0                    1
4              2.0            0.0                    1
…                …              …                    …
286881        56.0            0.0                    9
286882        56.0            0.0                   10
286883        57.0            0.0                    1
286884        57.0            0.0                    2
286885        57.0            0.0                    3

        learning_node_question_no  question_number_of_choice  is_correct  \
0                               1                          4         0.0
1                               2                          4         0.0
2                               1                          4         1.0
3                               1                          4         1.0
4                               1                          4         1.0
…                               …                          …       …
286881                          1                          3         1.0
286882                          2                          3         1.0
286883                          1                          3         1.0
286884                          1                          3         1.0
286885                          1                          3         1.0

        topic_WoE_Encode  sub_topic_WoE_Encode  learning_node_WoE_Encode  \
0               1.284016              1.351203                  1.351203
1               1.284016              1.351203                  1.351203
2               1.284016              1.351203                  1.351203
3               0.285275              0.583146                 -0.154151
4               0.285275              0.729961                  0.887303
…                      …                     …                     …
286881          1.969312              0.947891                  1.951845
286882          1.969312              0.947891                  1.951845
286883          1.809824              0.947891                  4.718499
286884          1.809824              0.947891                  3.601868
286885          1.809824              0.947891                  1.598856

        question_id_WoE_Encode  question_difficulty_None  \
0                     1.306252                         0
1                     1.306252                         0
2                     1.386294                         0
```

```
3                       0.405465                          0
4                      13.815511                          0
...                          ...                        ...
286881                  2.622436                          1
286882                  2.622436                          1
286883                  4.718499                          1
286884                  3.601868                          1
286885                  1.598856                          1

        question_difficulty_easy  question_difficulty_hard  \
0                              0                         0
1                              0                         0
2                              0                         0
3                              0                         0
4                              0                         0
...                          ...                       ...
286881                         0                         0
286882                         0                         0
286883                         0                         0
286884                         0                         0
286885                         0                         0

        question_difficulty_hots  question_difficulty_medium
0                              0                           1
1                              0                           1
2                              0                           1
3                              0                           1
4                              0                           1
...                          ...                         ...
286881                         0                           0
286882                         0                           0
286883                         0                           0
286884                         0                           0
286885                         0                           0

[286886 rows x 15 columns]
```

[59]:
```
describe.describe_data(train)
```

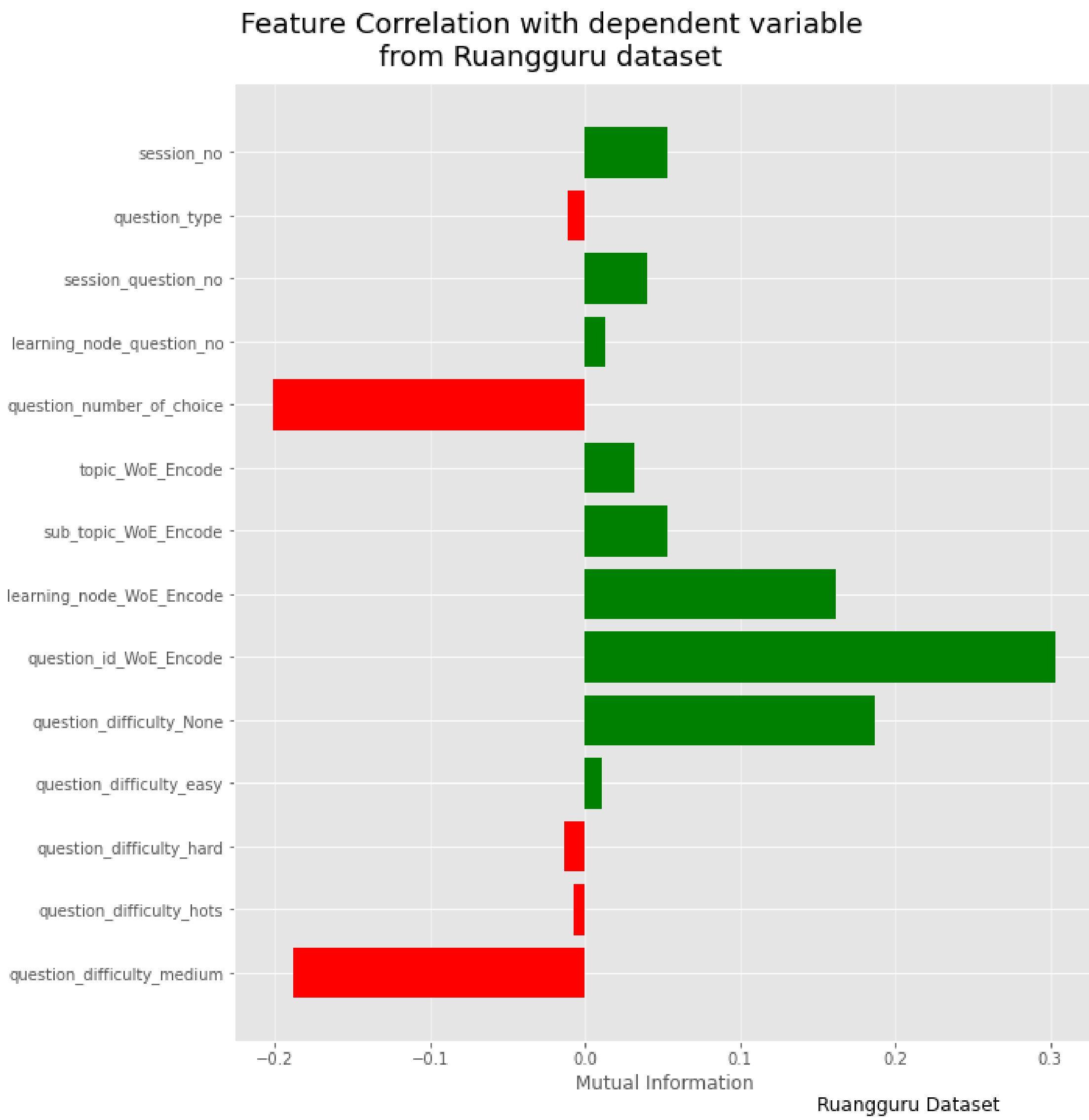
```
'table size 286886 x 15'

Dataframe has 15 columns.
There are 0 columns that have missing values.
```

[59]:
```
                column_names Data Type  Missing Values  % missing low Value  \
0                 session_no   float64               0        0.0         1
1              question_type   float64               0        0.0         0
2        session_question_no     int64               0        0.0         1
```

```
3     learning_node_question_no     int64             0       0.0        1
4     question_number_of_choice     int64             0       0.0        2
5                    is_correct   float64             0       0.0        0
6                topic_WoE_Encode float64             0       0.0    -9999
7            sub_topic_WoE_Encode float64             0       0.0    -9999
8          learning_node_WoE_Encode float64           0       0.0    -9999
9           question_id_WoE_Encode float64            0       0.0    -9999
10      question_difficulty_None     uint8            0       0.0        0
11      question_difficulty_easy     uint8            0       0.0        0
12      question_difficulty_hard     uint8            0       0.0        0
13      question_difficulty_hots     uint8            0       0.0        0
14    question_difficulty_medium     uint8            0       0.0        0

   Hi Value  stddev Value  unique
0      1311           164  1311.0
1         1             0     2.0
2        44             4    44.0
3        32             1    32.0
4         6             1     5.0
5         1             0     2.0
6        14           232  1019.0
7        14           391   807.0
8        14          1178  1369.0
9        14          2145  1125.0
10        0             0     2.0
11        0             0     2.0
12        0             0     2.0
13        0             0     2.0
14        0             0     2.0
```

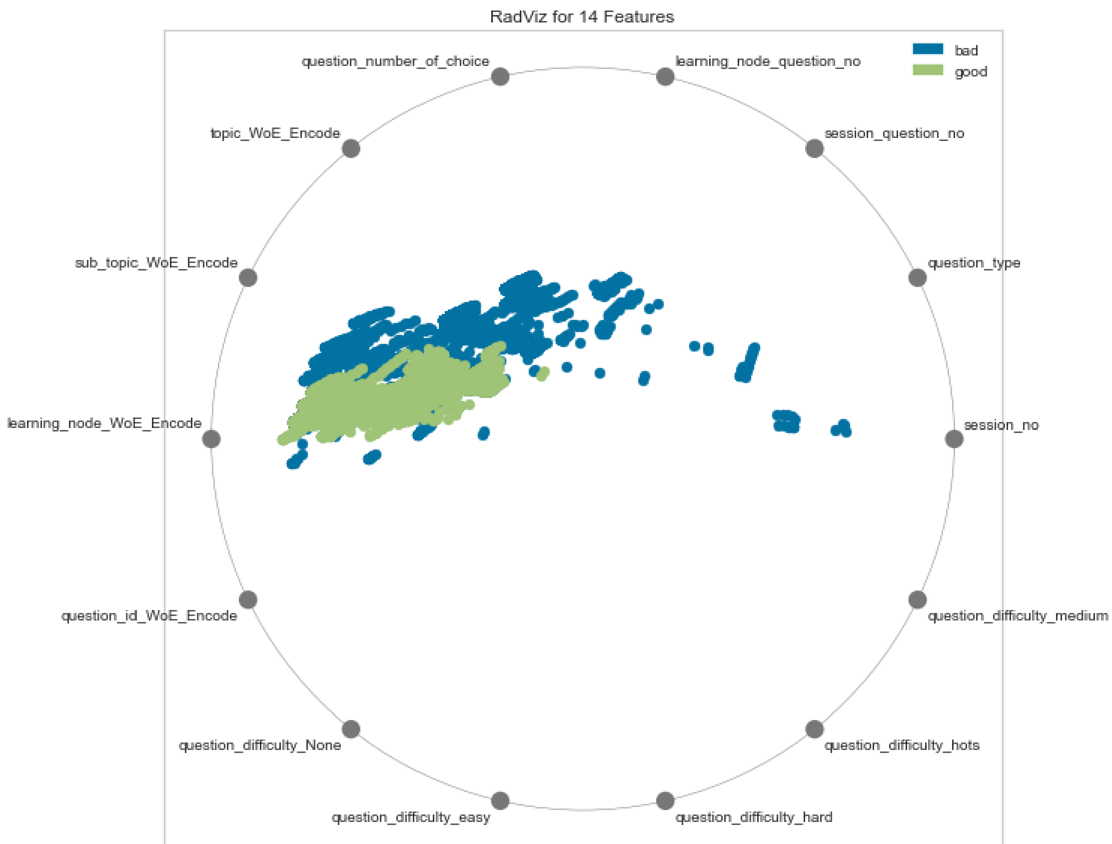
7.3.3 take a look to our relation of our dataset

[26]:
```
visual.label_corr(train,'is_correct',type_coor="pearson",
                  title="Ruangguru", footnote='Ruangguru Dataset')
```



as we can see, we got high positive corellation from `learning_node_WoE_Encode`, `question_id_WoE_Encode` and `question_difficulty_None` and high negative corellation from `question_number_of_choice` and `question_difficulty_medium`

[27]:
```
visual.radviz(train,'is_correct',labels=["bad","good"])
```

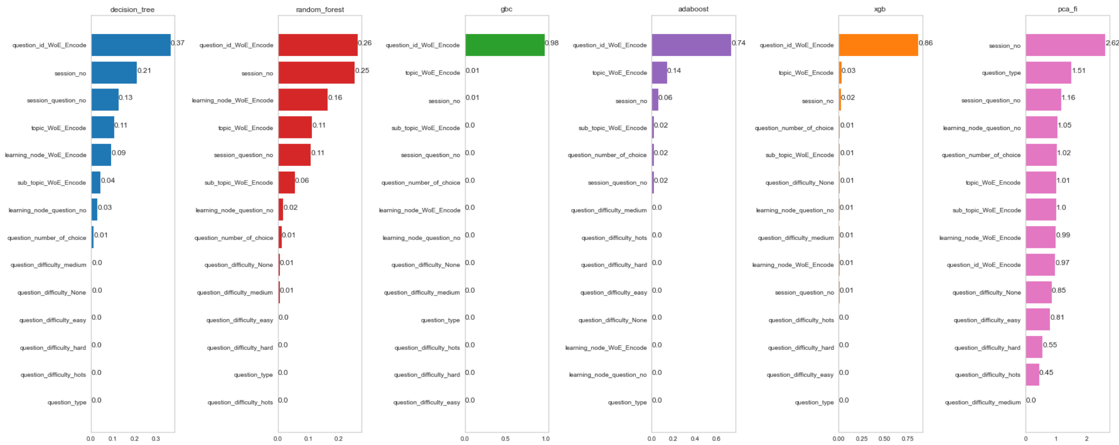


Firstly, from plot above we can see that our dataset has good separability between classes in label. secondly, from this plot we can conclude that we have opportunity to learn from our features set and chance our features just bunch of noise is low.

8 Feature Importance

[28]:
```
rest = feature_importance(train,'is_correct',20).plot_FI(["all"])
```

```
ursar
feature_importance
```



[31]:
```
rest
```

[31]:
```
                     features  decision_tree  random_forest     gbc  \
0                  session_no         0.2116         0.2533  0.0065
1               question_type         0.0002         0.0002  0.0000
2         session_question_no         0.1261         0.1087  0.0007
3   learning_node_question_no         0.0303         0.0178  0.0004
4   question_number_of_choice         0.0123         0.0123  0.0007
5              topic_WoE_Encode         0.1056         0.1125  0.0089
6          sub_topic_WoE_Encode         0.0447         0.0555  0.0013
7      learning_node_WoE_Encode         0.0936         0.1641  0.0005
8        question_id_WoE_Encode         0.3662         0.2626  0.9808
9    question_difficulty_None         0.0033         0.0059  0.0002
10   question_difficulty_easy         0.0011         0.0007  0.0000
11   question_difficulty_hard         0.0005         0.0004  0.0000
12   question_difficulty_hots         0.0003         0.0002  0.0000
13 question_difficulty_medium         0.0043         0.0059  0.0001

   adaboost     xgb  pca_fi
0      0.06  0.0248  2.6186
1      0.00  0.0000  1.5114
2      0.02  0.0093  1.1619
3      0.00  0.0113  1.0511
4      0.02  0.0134  1.0219
5      0.14  0.0318  1.0073
6      0.02  0.0119  1.0020
7      0.00  0.0105  0.9865
8      0.74  0.8646  0.9743
9      0.00  0.0116  0.8550
10     0.00  0.0000  0.8062
11     0.00  0.0000  0.5540
```

```
12       0.00  0.0000  0.4499
13       0.00  0.0110  0.0000
```

from feature importance above we found that `question_type` has low importance value and `question_id_WoE_Encode` has high importance value.

9 Model

9.1 Seperate feature and label set

[60]:
```
X = train.drop(["is_correct"], axis=1)
y = train["is_correct"]
```

9.2 Split data

this process we will split data to become train and validate before we apply our model to test dataset

[61]:
```
X_train, X_test, y_train, y_test = train_test_split(X,y,
                                                    test_size = 0.2,␣
 ↪random_state=None)
```

[62]:
```
print('X_train size shape= {0}' .format(X_train.shape))
print('X_test size shape= {0}' .format(X_test.shape))
print('y_train size shape= {0}' .format(y_train.shape))
print('y_test size shape= {0}' .format(y_test.shape))
```

```
X_train size shape= (229508, 14)
X_test size shape= (57378, 14)
y_train size shape= (229508,)
y_test size shape= (57378,)
```

9.3 Train the dataset with 5 fold and hyperparameter default

[63]:
```
result,proba = model.cv_model_train(X_train.to_numpy(), y_train.to_numpy(),
                    ['random_forest',"adaboost","gb","xgb",'naive_bayes','lr'],5)
```

```
Finished training for model:
Random Forest
Ada Boosting
Gradient Boosting
Extra Gradient Boosting
Logistic Regression
Naive Bayes
```

[64]:
```
result
```

[64]:
```
                 Method  accuracy  accuracy_std  balanced_acc  \
0     Gradient Boosting    0.7537        0.0028        0.7032
```

```
1  Extra Gradient Boosting    0.7536        0.0012        0.7027
2      Logistic Regression    0.7520        0.0017        0.7016
3             Ada Boosting    0.7519        0.0020        0.7016
4            Random Forest    0.7195        0.0012        0.6815
5              Naive Bayes    0.6905        0.0032        0.5664

   balanced_acc_std      F1  F1_std     AUC  AUC_std  AUC_ROC  AUC_ROC_std  \
0            0.0032  0.7440  0.0033  0.8906   0.0010   0.8191       0.0011
1            0.0026  0.7437  0.0019  0.8905   0.0008   0.8189       0.0007
2            0.0028  0.7423  0.0021  0.8898   0.0015   0.8178       0.0017
3            0.0044  0.7422  0.0016  0.8895   0.0016   0.8173       0.0017
4            0.0008  0.7154  0.0012  0.8608   0.0013   0.7778       0.0008
5            0.0011  0.6040  0.0041  0.7305   0.0019   0.6300       0.0013

   Recall  Recall_std  Precision  Precision_std  Fit Time  Pred Time
0  0.8785      0.0011     0.7711         0.0038   56.2884     0.2936
1  0.8791      0.0046     0.7707         0.0036   11.8784     0.2598
2  0.8762      0.0026     0.7704         0.0022    3.1922     0.1400
3  0.8759      0.0137     0.7705         0.0048   10.4964     0.6622
4  0.8133      0.0015     0.7659         0.0013   40.8637     4.5376
5  0.9964      0.0003     0.6763         0.0033    0.1732     0.1766
```

From the table above we got high AUC_ROC at `Gradient Boosting` model

9.4 Hyperparameter Tunning

[29]:
```python
param_grid = [
{
    'max_depth':[3,5,10],
    'n_estimators':[60,80,100],
    'learning_rate': [0.1,1,10]
}]
```

[30]:
```python
res_gs = tunning.gridsearch(X_train, y_train,param_grid,['gb'],
                           scoring='roc_auc',cv=3)
```

```
Fitting 3 folds for each of 27 candidates, totalling 81 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done  25 tasks      | elapsed:  4.4min
[Parallel(n_jobs=-1)]: Done  81 out of  81 | elapsed: 14.9min finished

Best parameter for gb =
learning_rate           :        0.1
max_depth               :        5
n_estimators            :        100
-----------------------------------------------------------------------
```

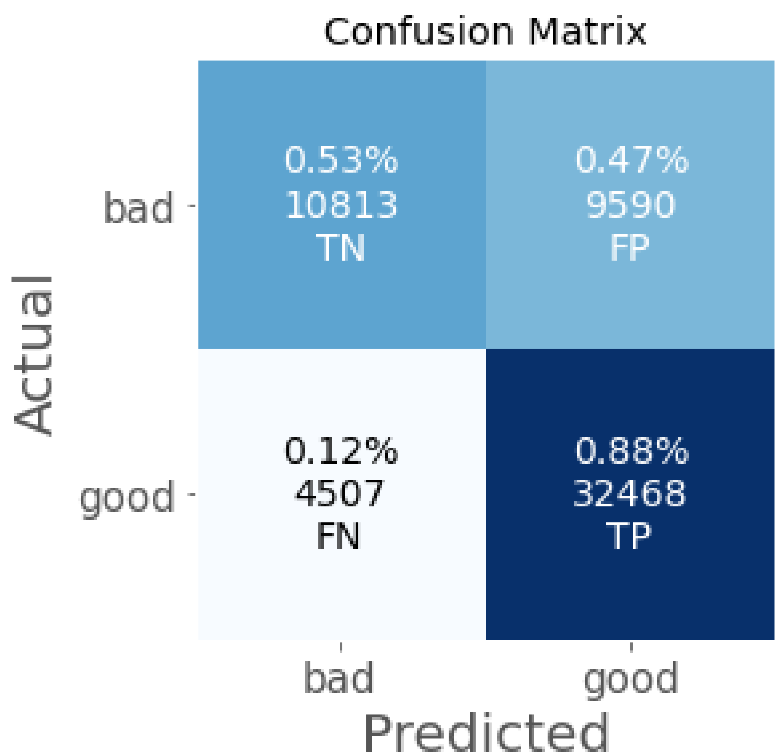
9.4.1 apply best param to model

[209]:
```
models,names_model,probs_model,probs_bool_model,pred_model,time_1,time_2 =␣
↪model.modeling(
   X_train.to_numpy(), X_test.to_numpy(), y_train.to_numpy(), y_test.
↪to_numpy(),list_model=['gb'])
```

```
we have done with these models:
Gradient_boosting_Classifier
```

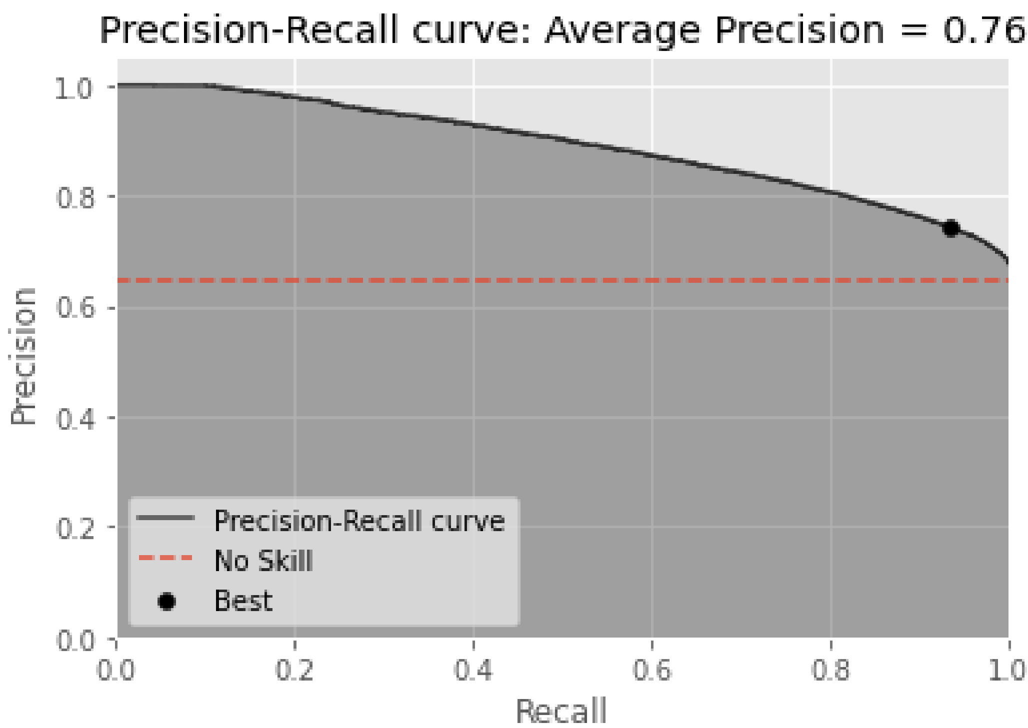
[210]:
```
scoring.print_score(y_test.to_numpy(),pred_model[0],y_probs=probs_model[0],
                    types='classification',labels=["bad","good"],
                    time1=time_1[0],time2=time_2[0],
                    X_train=None, y_train=None,X_test=None)
```

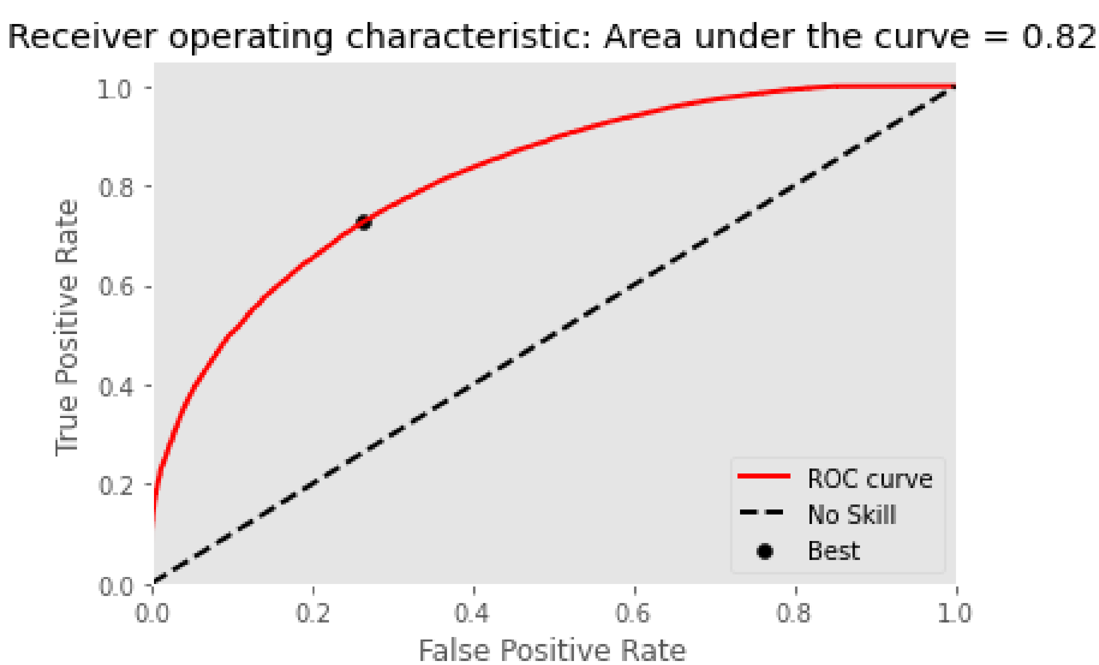
```
comfusion matrix =
[[10813  9590]
 [ 4507 32468]]
```




```
accuracy_score =  0.7543
balanced_accuracy_score =  0.704

precision score =  0.772
```

```
average precision score =  0.7564
recall score =  0.8781
Brier score loss (the smaller the better) =  0.1609

F1 score =  0.8216
F2 score =  0.8546
F3 score =  0.8662
F_beta score (0.5) =  0.7911
Matthews Correlation Coefficient score =  0.4416

AUC of Precision-Recall Curve on Testing =  0.8893
Best Threshold for Precision-Recall Curve = 0.426100
F-Score = 0.828
AUC of ROC =  0.8183

Best Threshold for ROC = 0.636000
G-Mean = 0.732
Best Threshold with Youden's J statistic = 0.636000

Cohens kappa =  0.4322
Gini =  0.7786

Expected Approval Rate =  0.733
Expected Default Rate =  0.228

classification_report
              precision    recall  f1-score   support

         0.0       0.71      0.53      0.61     20403
         1.0       0.77      0.88      0.82     36975

    accuracy                           0.75     57378
   macro avg       0.74      0.70      0.71     57378
weighted avg       0.75      0.75      0.74     57378
```






```
time span=  0:00:42.855037
```

from steps above we got some results: AUC of ROC = 0.8191 for training data with Gradient Boosting model we use these parametes from hyperparameter tunning process: learning rate : 0.1 max depth : 5 n estimators : 100 AUC of ROC = 0.8183 for validate data

10 Using Test dataset

10.1 Feature engineering for test dataset

[182]:
```
col = ['session_no', 'topic', 'sub_topic',
       'learning_node', 'question_id',"question_type", 'session_question_no',
       'learning_node_question_no','question_difficulty',
       'question_number_of_choice']
```

[183]:
```
test = test[col]
```

[184]:
```
for i in test[~test['topic'].isin(train['topic'])]["topic"].values:
    topic_res = topic_res.append(pd.Series([0], index=[i]))
```

[185]:
```
for i in test[~test['sub_topic'].isin(train['sub_topic'])]["sub_topic"].values:
    sub_topic_res = sub_topic_res.append(pd.Series([0], index=[i]))
```

[186]:
```
for i in test[~test['question_id'].isin(train['question_id'])]["question_id"].
 ↪values:
    question_id_res = question_id_res.append(pd.Series([0], index=[i]))
```

[187]:
```
for i in test[~test['learning_node'].
 ↪isin(train['learning_node'])]["learning_node"].values:
    learning_node_res = learning_node_res.append(pd.Series([0], index=[i]))
```

[189]:
```
learning_node_res = learning_node_res.groupby(learning_node_res.index).first()
question_id_res = question_id_res.groupby(question_id_res.index).first()
```

[190]:
```
test.loc[:,'topic_WoE_Encode'] = test['topic'].map(topic_res)
test.loc[:,'sub_topic_WoE_Encode'] = test['sub_topic'].map(sub_topic_res)
test.loc[:,'learning_node_WoE_Encode'] = test['learning_node'].
 ↪map(learning_node_res)
test.loc[:,'question_id_WoE_Encode'] = test['question_id'].map(question_id_res)
```

[191]:
```
test = test.drop(columns = ["topic",'sub_topic','learning_node','question_id'])
```

[192]:
```
test['question_difficulty'] = test['question_difficulty'].replace(np.nan,␣
 ↪"None")
test = fe.encode(test,['question_difficulty'],"ohe")
```

[193]:
```
test['question_type'].unique()
```

[193]:
```
array(['Single choice', 'Multi choice'], dtype=object)
```

[194]:
```
key = [{0.0:"Single choice", 1.0:'Multi choice'}]
test,dicts = fe.mapping(test,['question_type'],"def",key)
```

[195]:
```
test
```

[195]:
```
      session_no  question_type  session_question_no  \
0            2.0            0.0                    2
1           11.0            0.0                    6
2            4.0            0.0                    8
3           10.0            0.0                    7
4            3.0            0.0                    9
…            …              …                    …
6995        18.0            0.0                    1
6996         1.0            0.0                    6
6997         6.0            0.0                   14
6998         4.0            0.0                   14
6999        57.0            0.0                    4

      learning_node_question_no  question_number_of_choice  topic_WoE_Encode  \
0                             2                          4          1.284016
1                             2                          4          0.198851
2                             2                          4          0.173746
3                             1                          4          0.374049
4                             3                          4          0.127388
…                           …                          …               …
6995                          1                          5          0.312490
6996                          1                          4          0.186251
6997                          2                          5          0.530628
6998                          2                          4         -0.201866
6999                          1                          3          1.809824

      sub_topic_WoE_Encode  learning_node_WoE_Encode  question_id_WoE_Encode  \
0                 1.351203                  1.351203                1.306252
1                -0.048790                  0.538997                1.252763
2                 0.947891                  0.243346                0.287682
3                 0.947891                  1.321756                0.451985
4                 0.072162                  0.451985                0.916291
…                   …                        …                      …
6995              0.947891                  0.274279               -0.305163
6996             -0.315853                 -0.628609            -9999.000000
6997             13.815511                 13.815511                0.000000
6998              0.000000                  1.386294               13.815511
6999              0.947891                  0.603916                0.603916

      question_difficulty_None  question_difficulty_easy  \
0                            0                         0
1                            0                         0
```

```
2                              1                          0
3                              1                          0
4                              0                          0
…                          …                          …
6995                           1                          0
6996                           0                          0
6997                           0                          0
6998                           0                          0
6999                           1                          0

      question_difficulty_hard  question_difficulty_hots  \
0                              0                          0
1                              0                          0
2                              0                          0
3                              0                          0
4                              0                          0
…                          …                          …
6995                           0                          0
6996                           0                          0
6997                           0                          0
6998                           0                          0
6999                           0                          0

      question_difficulty_medium
0                              1
1                              1
2                              0
3                              0
4                              1
…                            …
6995                           0
6996                           1
6997                           1
6998                           1
6999                           0

[7000 rows x 14 columns]
```

[196]:
```
describe.describe_data(test)
```

```
'table size 7000 x 14'

Dataframe has 14 columns.
There are 0 columns that have missing values.
```

[196]:
```
                 column_names Data Type  Missing Values  % missing low Value  \
0                  session_no   float64               0        0.0         1
1               question_type   float64               0        0.0         0
```

```
2          session_question_no     int64           0        0.0         1
3     learning_node_question_no     int64           0        0.0         1
4      question_number_of_choice     int64           0        0.0         2
5               topic_WoE_Encode   float64           0        0.0     -9999
6           sub_topic_WoE_Encode   float64           0        0.0     -9999
7       learning_node_WoE_Encode   float64           0        0.0     -9999
8         question_id_WoE_Encode   float64           0        0.0     -9999
9       question_difficulty_None     uint8           0        0.0         0
10      question_difficulty_easy     uint8           0        0.0         0
11      question_difficulty_hard     uint8           0        0.0         0
12      question_difficulty_hots     uint8           0        0.0         0
13    question_difficulty_medium     uint8           0        0.0         0

   Hi Value  stddev Value   unique
0      1311            30    116.0
1         1             0      2.0
2        45             5     27.0
3        33             1      9.0
4         5             1      4.0
5        14           585    851.0
6        14           597    702.0
7        14          1718   1138.0
8        14          2634    872.0
9         0             0      2.0
10        0             0      2.0
11        0             0      2.0
12        0             0      2.0
13        0             0      2.0
```

10.2 apply model to test dataset

[197]:
```python
y_probs_test = models[0].predict_proba(test)[:, 1]
```

[200]:
```python
y_probs_test = pd.Series(y_probs_test)
```

10.3 create submission file

[206]:
```python
y_probs_test.to_csv( 'submission.
↪csv',index=True,index_label=['row_id'],header=['is_correct'])
```

11 Notes

this result is far from the best result and we can improve at some process, such as:

1. if we got correct value for "topic",'sub_topic','learning_node','question_id' there is probability to get better result.

2. Other supporting features can also be added (that need to be consulted back to the experts) to improve the generalization of the model
3. using more feature engineering to get more detail dataset.
4. I've done smote and near miss process but the result is lower than what we have in this result.
5. try to find the best value for hyperparameter and more wider value to get better result and dont stuck in the local optimum / minimum
6. try to use other hyperparameter tunning such as nature inspired algorithms (although the process will be longer)

[ ]:

```

```