

EDA_WM-BrianMc-topics-Method2-heat_map-100-clusters-all_data

February 22, 2018

In [1]: '''
MIT License

Copyright (c) 2018 Brian McKean

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

'''

Out[1]: '\nMIT License\n\nCopyright (c) 2018 Brian McKean\n\nPermission is hereby granted, free

In [2]: import pymongo
import pandas as pd
import numpy as np

from pymongo import MongoClient
from bson.objectid import ObjectId

import datetime

import matplotlib.pyplot as plt

```

from collections import defaultdict

%matplotlib inline
import json
plt.style.use('ggplot')

import seaborn as sns

from math import log10, floor

from time import time

from sklearn.feature_extraction.text import TfidfVectorizer, CountVectorizer

from sklearn.cluster import KMeans, MiniBatchKMeans

```

1 CU Woot Math Method 2 for unsupervised discovery of new behavior traits

- 1.1 1) Convert response field dictionary into a document
- 1.2 2) Develop word vector using term frequency - inverse document frequency
- 1.3 3) Use K-Means to cluster documents
- 1.4 4) Map traits to clusters to validate technique

In the first results presented to Woot Math a 100K sample of the entire data set was chosen. In this report, I'll start with the same type of analysis to develop the same heat map. In the meeting Sean and Brent suggested using just one of the qual_id and repeat the experiment and then look at the samples in clusters without traits. I'll do that in a subsequent analysis

1.5 Part 1. Heat map with 100 K sample of all qual_id's

In [3]: *## Connect to local DB*

```

client = MongoClient('localhost', 27017)
print ("Setup db access")

```

Setup db access

In [4]: #
Get collections from mongodb
#

```

#db = client.my_test_db
db = client.test

In [5]: chunk = 100000
        start = 0
        end = start + chunk

In [6]: #reponses = db.anon_student_task_responses.find({'correct':False})[start:end]
        # reponses = db.anon_student_task_responses.find()[start:end]
        reponses = db.anon_student_task_responses.find()

In [7]: df_responses = pd.DataFrame(list(reponses))

In [8]: print (df_responses.shape)

(10750532, 27)

In [9]: ## Make the documents to be analyzed

In [10]: ## Functions for turning dictionary into document

def make_string_from_list(key, elem_list):
    # Append key to each item in list
    ans = ''
    for elem in elem_list:
        ans += key + '_' + elem

def make_string(elem, key=None, top=True):
    ans = ''
    if not elem:
        return ans
    if top:
        top = False
        top_keys = []
        for idx in range(len(elem.keys())):
            top_keys.append(True)

    for idx, key in enumerate(elem.keys()):
        if top_keys[idx]:
            top = True
            top_keys[idx] = False
            ans += ' '
        else:
            top = False
        ans += key + '_'
    return ans

```

```

#print ('ans = ', ans)
#print (type(elem[key]))
if type(elem[key]) is str or \
    type(elem[key]) is int:
    #print ('add value', elem[key])
    value = str(elem[key])
    #ans += key + '_' + value + ' ' + value + ' '
    ans += key + '_' + value + ' '
elif type(elem[key]) is list:
    #print ('add list', elem[key])
    temp_elem = dict()
    for item in elem[key]:
        temp_elem[key] = item
        ans += make_string(temp_elem, top)
elif type(elem[key]) is dict:
    #print ('add dict', elem[key])
    for item_key in elem[key].keys():
        temp_elem = dict()
        temp_elem[item_key] = elem[key][item_key]
        ans += key + '_' + make_string(temp_elem, top)
elif type(elem[key]) is float:
    #print ('add dict', elem[key])
    sig = 2
    value = elem[key]
    value = round(value, sig-int(
        floor(log10(abs(value))))-1)
    value = str(value)
    #ans += key + '_' + value + ' ' + value + ' '
    ans += key + '_' + value + ' '
    # ans += ' ' + key + ' '
    #print ('not handled', elem[key])

return ans

```

In [11]: *# Makes the cut & paste below easier*
df3 = df_responses

In [12]: df3['response_doc'] = df3['response'].map(make_string)

In [13]: df3['response_doc'] = df3['response_doc'].map(lambda x: x + ' ')
df3['response_doc'] = df3['response_doc'].map(lambda x: x.replace('/', '_'))
df3['response_doc'] = df3['response_doc'] + ' ' + df3['txt']
df3['response_doc'] = df3['response_doc'].map(lambda x: x + ' ')
df3['response_doc'] = df3['response_doc'].map(lambda x: x.replace("\n", ""))
df3['response_doc'] = df3['response_doc'].map(lambda x: x.replace("?", " "))

1.6 Sample Documents

```
In [14]: for idx in range(20):
    print ("Sample number:", idx, "\n", df3.iloc[idx]['response_doc'])

Sample number: 0
    fraction_cblock_chains_right_442 fraction_cblock_chains_sum_numerator_1 sum_denominator_2
Sample number: 1
    fraction_cblock_total_count_4 plain_image_groups_total_1 plain_image_groups_url_assets cms
Sample number: 2
    fraction_cblock_chains_left_176 fraction_cblock_chains_lcm_sum_numerator_2 lcm_sum_denomi
Sample number: 3
    fraction_cblock_chains_left_176 fraction_cblock_chains_lcm_sum_numerator_1 lcm_sum_denomi
Sample number: 4
    fraction_circleContainment [Fraction] 1_2 lcm_sum_numerator_4 lcm_sum_denominator_8 lcm_s
Sample number: 5
    image_object_groups_total_6 image_object_groups_on_3 image_object_groups_url_assets_object
Sample number: 6
    Shade 1/4 of the circle.answer={:n=>3, :d=>12}
Sample number: 7
    Shade 1/3 of the rectangle.answer={:n=>2, :d=>6}
Sample number: 8
    fraction_circle_groups_x_512 fraction_circle_groups_scale_1 fraction_circle_groups_chains
Sample number: 9
    fraction_circle_groups_x_512 fraction_circle_groups_scale_1.0 fraction_circle_groups_chai
Sample number: 10
    fraction_circle_groups_x_512 fraction_circle_groups_scale_1.0 fraction_circle_groups_chai
Sample number: 11
    radio_choice_C radio_group_problem_choice_C radio_group_problem_text_3_6 radio_text_3_6
Sample number: 12
    fraction_cblock_chains_sum_denominator_10 sum_numerator_1 sum __as3_type_Fraction fraction
Sample number: 13
    whole_fraction_input_value_4_6 fraction_cblock_chains_sum_denominator_3 sum_numerator_2
Sample number: 14
    plain_image_groups_total_1 plain_image_groups_url_assets cms_wootmath_fractions_number_line
Sample number: 15
    input_8 One yard on the number line is divided intoAnswer: sixths
Sample number: 16
    numberline_associations_position_580.0 numberline_associations_pos_value_1.0 numberline_as
Sample number: 17
    plain_image_groups_total_1 plain_image_groups_url_assets cms_wootmath_fractions_number_line
Sample number: 18
    whole_fraction_input_value_1_3 fraction_cblock_chains_sum_denominator_1 sum_numerator_1
Sample number: 19
    whole_fraction_input_value_3_4 fraction_cblock_chains_sum_denominator_4 sum_numerator_3
```

```
In [15]: data_samples = df3['response_doc']
```

```
In [16]: n_features = 1000
         n_samples = len(data_samples)
         n_topics = 50
         n_top_words = 20
```

```
In [17]: print("Extracting tf-idf features ...")
         tfidf_vectorizer = TfidfVectorizer(max_df=0.95, min_df=2,
                                             max_features=n_features,
                                             stop_words='english')
         t0 = time()
         tfidf = tfidf_vectorizer.fit_transform(data_samples)
         print("done in %0.3fs." % (time() - t0))
```

Extracting tf-idf features ...
done in 653.399s.

```
In [18]: # Number of clusters
         true_k = 100

         km = MiniBatchKMeans(n_clusters=true_k, init='k-means++', n_init=1,
                               init_size=1000, batch_size=1000, random_state=42)
```

```
In [19]: print("Clustering with %s" % km)
         t0 = time()
         km.fit(tfidf)
         print("done in %0.3fs" % (time() - t0))
         print()
```

Clustering with MiniBatchKMeans(batch_size=1000, compute_labels=True, init='k-means++',
 init_size=1000, max_iter=100, max_no_improvement=10,
 n_clusters=100, n_init=1, random_state=42, reassignment_ratio=0.01,
 tol=0.0, verbose=0)
done in 133.809s

```
In [20]: print("Top terms per cluster:")
```

```
order_centroids = km.cluster_centers_.argsort()[:, ::-1]
terms = tfidf_vectorizer.get_feature_names()
for i in range(true_k):
    print("Cluster %d:\n" % i, end='')
    for ind in order_centroids[i, :30]:
        print(' --- %s\n' % terms[ind], end='')
    print()
```

Top terms per cluster:
Cluster 0:

```
--- fraction_cblock_chains_
--- pieces_1_6
--- lcm_sum_
--- sum_
--- __as3_type_fraction
--- denominator_6
--- numerator_1
--- denominator_1
--- fraction_cblock_counts_
--- bar1_
--- denominator_3
--- numerator_2
--- unit2_
--- unit1_
--- numerator_5
--- fraction_cblock_containment_
--- left_90
--- fraction
--- pieces_1
--- left_130
--- denominator_2
--- numerator_4
--- numerator_6
--- pieces_1_3
--- right_780
--- piece0_
--- left_176
--- bar
--- right_820
--- object
```

Cluster 1:

```
--- pieces_1_4
--- fraction_circle_groups_
--- 1_
--- chains_
--- fraction
--- sum_
--- lcm_sum_
--- fraction_circle_counts_
--- denominator_4
--- __as3_type_fraction
--- input_a_4
--- scale_1
--- 1_4_4
--- input_4
--- blues
--- circle
```

```
--- x_300
--- fraction_circleContainment_
--- fraction_circle_total_count_5
--- y_300
--- dark
--- black
--- numerator_4
--- 1_1
--- pieces_1
--- left_180
--- numerator_1
--- equals
--- right_180
--- equal
```

Cluster 2:

```
--- fraction_circle_groups_
--- unit_
--- lcm_sum_
--- sum_
--- fraction_circle_counts_
--- circle1_
--- fraction_circle_total_count_2
--- numerator_1
--- __as3_type_fraction
--- fraction_circleContainment_
--- y_350
--- scale_0
--- 1_1
--- pieces_1_2
--- scale_1
--- pieces_1
--- unit2_
--- fraction
--- denominator_2
--- x_300
--- circle
--- pieces_1_4
--- x_512
--- black
--- answer
--- pieces_1_3
--- unit1_
--- pieces_1_6
--- 1_2_1
--- denominator_4
```

Cluster 3:

```
--- numberline_associations_
--- obj_value_a
--- line
--- location
--- number
--- correct
--- drag
--- pos_value_2
--- pos_value_0
--- pos_value_1
--- input_8
--- input_12
--- input_10
--- miles
--- friend
--- answer
--- input_6
--- input_16
--- input_9
--- left
--- mile
--- 12
--- position_450
--- input_4
--- walked
--- eat
--- walk
--- 25
--- 17
--- 10
```

Cluster 4:

```
--- using
--- model
--- answer
--- fraction
--- equivalent
--- pieces
--- size
--- greater
--- cover
--- thirds
--- equal
--- fourths
--- dark
--- sixths
--- halves
--- pinks
```

```
--- gray
--- grays
--- blues
--- piece
--- browns
--- sized
--- yellows
--- yellow
--- equally
--- object
--- fifths
--- pink
--- brown
--- eighths
```

Cluster 5:

```
--- fraction_cblock_chains_
--- sum_
--- lcm_sum_
--- denominator_12
--- __as3_type_fraction
--- numerator_1
--- pieces_1_12
--- denominator_1
--- left_90
--- fraction_cblock_counts_
--- top_225
--- fraction
--- 1_
--- denominator_4
--- right_780
--- denominator_3
--- pieces_1
--- 12
--- unit2_
--- right_262
--- left_147
--- right_147
--- left_125
--- denominator_2
--- right_204
--- left_205
--- pieces_1_3
--- pieces_1_4
--- pieces_1_6
--- denominator_8
```

Cluster 6:

```
--- plain_image_groups_
--- url_assets_cms_wootmath_fractions_misc_objects_ant_alt
--- url_assets_cms_wootmath_fractions_misc_objects_ladybug_alt
--- bugs
--- ladybugs
--- swf
--- total_2
--- form
--- simplest
--- total_4
--- whole_
--- total_3
--- enter
--- num_1
--- fraction
--- fraction_input_value_1_2
--- den_2
--- answer
--- den_3
--- total_6
--- fraction_input_value_1_3
--- den_4
--- num_2
--- fraction_input_value_2_3
--- total_9
--- equivalent
--- fraction_input_value_1_4
--- num_3
--- total_8
--- fraction_input_value_3_4
```

Cluster 7:

```
--- polygon
--- match
--- shade
--- fraction_input_value_
--- fraction
--- input_a_
--- choose
--- comparison
--- correct
--- 1_6
--- 2_6
--- 2_4
--- 5_6
--- 2_5
--- 4_6
--- 2_8
```

```
--- 1_8
--- 3_6
--- 6_8
--- 4_8
--- 1_4
--- 3_5
--- 3_4
--- 1_5
--- fraction_circle_total_count_6
--- fraction_circle_total_count_9
--- fraction_circle_total_count_8
--- fraction_circle_counts_
--- fraction_circle_groups_
--- fraction_circle_total_count_7
```

Cluster 8:

```
--- image_object_groups_
--- shade
--- swf
--- 14
--- off_2
--- answer
--- total_8
--- on_3
--- on_4
--- off_6
--- off_4
--- on_2
--- off_1
--- off_3
--- total_12
--- 11
--- 12
--- 13
--- total_6
--- on_0
--- url_assets_objects_singles_octopus
--- on_1
--- url_assets_objects_singles_cat
--- cats
--- total_9
--- 10
--- url_assets_objects_singles_piranha
--- 15
--- total_3
--- light
```

Cluster 9:

```
--- whole_
--- den_5
--- fraction
--- enter
--- answer
--- num_4
--- greatest
--- num_5
--- num_1
--- den_6
--- den_8
--- den_12
--- num_3
--- fraction_input_value_1_5
--- den_7
--- smaller
--- fraction_input_value_5_6
--- different
--- greater
--- fractions
--- 12
--- form
--- simplest
--- num_7
--- fraction_input_value_1_4
--- den_4
--- 100
--- improper
--- fraction_input_value_4_6
--- fraction_input_value_3_6
```

Cluster 10:

```
--- fraction_cblock_chains_
--- lcm_sum_
--- sum_
--- __as3_type_fraction
--- numerator_1
--- left_100
--- bar1_
--- bar2_
--- denominator_2
--- denominator_1
--- right_790
--- fraction_cblock_counts_
--- pieces_1_10
--- fraction_cblock_containment_
--- pieces_1_2
--- pieces_1_6
```

```
--- pieces_1
--- right_445
--- bar0_
--- denominator_4
--- pieces_1_4
--- denominator_3
--- numerator_2
--- pieces_1_8
--- denominator_6
--- 1_2
--- denominator_10
--- top_253
--- top_360
--- numerator_3
```

Cluster 11:

```
--- object
--- decimals
--- shown
--- input_a_
--- choose
--- input_
--- comparison
--- correct
--- model
--- answer
--- decimal
--- enter
--- 24
--- 14
--- pink
--- 15
--- bar
--- black
--- fraction
--- fraction_circle_total_count_6
--- fraction_circle_total_count_5
--- fraction_cblock_total_count_8
--- fraction_cblock_total_count_6
--- fraction_circle_total_count_4
--- fraction_circle_total_count_3
--- fraction_circle_total_count_2
--- fraction_cblock_total_count_7
--- fraction_circle_counts_
--- fraction_circle_total_count_16
--- fraction_circle_total_count_15
```

Cluster 12:

```
--- pieces_1_12
--- fraction_circle_groups_
--- chains_
--- fraction_circle_counts_
--- sum_
--- lcm_sum_
--- scale_1
--- fraction
--- denominator_12
--- __as3_type_fraction
--- 1_3_
--- frac_piece_
--- fraction_circle_containment_
--- piece1_
--- 1_4_
--- piece_0_
--- pieces_1_4
--- numerator_1
--- reds
--- 1_12_3
--- piece
--- y_300
--- 12
--- x_300
--- red
--- circle1_
--- fraction_circle_total_count_5
--- right_270
--- left_0
--- numerator_3
```

Cluster 13:

```
--- arrange
--- order
--- greatest
--- boxes
--- fractions
--- drag
--- fraction
--- 81
--- 42
--- 51
--- 43
--- 52
--- 32
--- 31
--- 63
--- 83
```

```
--- 54
--- 123
--- 44
--- 85
--- 12
--- answer
--- 45
--- 62
--- 15
--- 14
--- 18
--- 125
--- 10
--- 19
```

Cluster 14:

```
--- fraction_circle_groups_
--- scale_0
--- fraction_circle_counts_
--- piece
--- pizza
--- scale_1
--- fraction_circle_total_count_1
--- x_675
--- x_200
--- ate
--- pieces_1
--- x_811
--- box
--- y_300
--- answer
--- fraction_circle_total_count_4
--- x_550
--- unit_
--- unit
--- pieces
--- friend
--- y_415
--- 1_1
--- y_450
--- drag
--- pieces_1_10
--- half
--- 1_10_1
--- x_475
--- y_375
```

Cluster 15:

```
--- eqn_2
--- input_2
--- input_a_2
--- missing
--- numerator
--- bitmap_text_interp_
--- bitmap_text_inputs_
--- enter
--- 2_3
--- eqn_1_2
--- 2_4
--- 2_6
--- answer
--- 15
--- 10
--- 2_8
--- 12
--- numbers
--- fraction
--- 50
--- complete
--- 19
--- 2_5
--- denominator
--- fractions
--- 80
--- fraction_cblock_chains_
--- numerator_22
--- fraction_circle_groups_
--- sum_
```

Cluster 16:

```
--- divide
--- lengths
--- length
--- yards
--- yard
--- fraction_input_value_
--- equal
--- line
--- number
--- bar
--- whole_
--- enter
--- fraction
--- den_input_8
--- den_input_6
--- num_1
```

```
--- answer
--- den_8
--- den_input_4
--- den_6
--- den_2
--- num_2
--- den_4
--- num_3
--- den_3
--- num_4
--- num_5
--- parts
--- num_6
--- mile
```

Cluster 17:

```
--- fraction_cblock_chains_
--- sum_
--- lcm_sum_
--- __as3_type_fraction
--- numerator_1
--- left_175
--- right_865
--- denominator_1
--- denominator_12
--- unit3_
--- denominator_8
--- unit2_
--- denominator_4
--- pieces_1_6
--- fraction_cblock_counts_
--- unit1_
--- right_347
--- denominator_6
--- pieces_1
--- pieces_1_12
--- top_460
--- pieces_1_8
--- pieces_1_4
--- top_550
--- top_640
--- fraction_cblock_containment_
--- left_347
--- denominator_2
--- right_261
--- denominator_3
```

Cluster 18:

```
--- pieces_1_10
--- fraction_cblock_chains_
--- fraction_circle_groups_
--- lcm_sum_
--- sum_
--- denominator_10
--- __as3_type_fraction
--- chains_
--- numerator_1
--- fraction_circle_counts_
--- unit_
--- fraction
--- 10
--- denominator_5
--- plain_image_groups_
--- 1_2_
--- denominator_1
--- numerator_9
--- fraction_cblock_counts_
--- 1_5_
--- fraction_circle_containment_
--- circle1_
--- pieces_1
--- scale_1
--- bar1_
--- pieces_1_5
--- 1_
--- unit1_
--- unit2_
--- purples
```

Cluster 19:

```
--- takes
--- flour
--- make
--- pizzas
--- apple
--- cake
--- pie
--- pizza
--- input_a_4
--- input_a_6
--- input_4
--- input_6
--- answer
--- input_12
--- input_3
--- input_a_9
```

```
--- input_a_3
--- input_9
--- input_2
--- input_a_8
--- cookies
--- input_a_2
--- input_8
--- 12
--- chocolate
--- object
--- makes
--- used
--- num_1
--- left
```

Cluster 20:

```
--- pieces_1_8
--- fraction_circle_groups_
--- chains_
--- fraction_circle_counts_
--- lcm_sum_
--- sum_
--- 1_4_
--- pieces_1_4
--- piece_0_
--- denominator_8
--- __as3_type_fraction
--- unit_
--- fraction_circle_containment_
--- scale_1
--- fraction
--- scale_0
--- denominator_4
--- left_0
--- x_512
--- numerator_2
--- numerator_1
--- 1_8_2
--- y_300
--- unit2_
--- pieces_1
--- cover
--- unit1_
--- 1_1
--- right_270
--- pieces
```

Cluster 21:

```
--- plain_image_groups_
--- fraction_cblock_chains_
--- total_1
--- swf
--- pieces_1_8
--- pieces_1_6
--- lcm_sum_
--- sum_
--- __as3_type_fraction
--- left_96
--- url_assets cms wootmath fractions number_line_markers_start_marker
--- figure
--- far
--- traveled
--- use
--- denominator_8
--- fraction_cblock_counts_
--- url_assets cms wootmath fractions number_line_markers_end_marker
--- denominator_6
--- pieces
--- travel
--- numerator_1
--- bitmap_text_inputs_
--- bitmap_text_interp_
--- ladybug
--- did
--- answer
--- yard
--- snail
--- eighths
```

Cluster 22:

```
--- radio_text_
--- choose
--- comparison
--- input_
--- correct
--- answer
--- input_a_
--- greater
--- 12
--- fraction_circle_total_count_14
--- fraction_circle_total_count_15
--- fraction_circle_total_count_16
--- fraction_circle_total_count_4
--- fraction_circle_total_count_2
--- fraction_circle_total_count_3
--- fraction_circle_total_count_12
```

```
--- fraction_circle_total_count_5
--- fraction_circle_total_count_6
--- fraction_circle_total_count_13
--- youranswer
--- fraction_circle_total_count_11
--- fraction_circle_total_count_10
--- fraction_circle_total_count_7
--- fraction_circle_groups_
--- fraction_circle_counts_
--- fraction_circleContainment_
--- fraction_cblock_total_count_9
--- fraction_cblock_total_count_8
--- fraction_cblock_total_count_7
--- fraction_cblock_total_count_6
```

Cluster 23:

```
--- pieces_1_4
--- fraction_circle_groups_
--- chains_
--- lcm_sum_
--- sum_
--- fraction_circle_counts_
--- denominator_4
--- unit1_
--- __as3_type_fraction
--- scale_0
--- fraction_circleContainment_
--- unit2_
--- piece_0_
--- circle1_
--- unit_
--- pieces_1
--- numerator_1
--- scale_1
--- left_270
--- y_300
--- 1_4_2
--- numerator_3
--- 1_1
--- right_180
--- right_270
--- numerator_2
--- denominator_2
--- fraction
--- object
--- left_0
```

Cluster 24:

```
--- object
--- form
--- simplest
--- mixed
--- enter
--- whole_1
--- fraction_input_value_1
--- number
--- answer
--- num_1
--- whole_2
--- fraction_input_value_2
--- num_3
--- swam
--- den_2
--- num_2
--- mile
--- den_4
--- gave
--- den_3
--- whole_
--- express
--- biked
--- total
--- 3_4
--- pizza
--- den_5
--- den_6
--- 1_2
--- mult_d_1_
```

Cluster 25:

```
--- pieces_1_15
--- fraction_cblock_chains_
--- sum_
--- lcm_sum_
--- denominator_15
--- __as3_type_fraction
--- fraction_circle_groups_
--- numerator_1
--- chains_
--- 1_3_
--- fraction
--- 1_5_
--- fraction_cblock_counts_
--- denominator_1
--- 15
--- fraction_circle_counts_
```

```
--- denominator_3
--- left_90
--- pieces_1_3
--- denominator_5
--- unit_
--- numerator_2
--- pieces_1_5
--- scale_1
--- unit1_
--- pieces_1_12
--- pieces_1
--- greens
--- fraction_circleContainment_
--- right_780
```

Cluster 26:

```
--- represented
--- grid
--- enter
--- answer
--- decimal
--- input_0
--- input_a_0
--- pieces
--- drag
--- input_a_
--- input_
--- 45
--- 31
--- 44
--- 33
--- 32
--- 34
--- 30
--- 51
--- 43
--- 75
--- 52
--- 42
--- 54
--- 50
--- 55
--- 40
--- 62
--- 63
--- 58
```

Cluster 27:

```
--- box
--- drag
--- tothe
--- answer
--- ans1
--- equivalent
--- fractions
--- denominator
--- ans0
--- numerator
--- fraction
--- shown
--- homework
--- person
--- amounts
--- greater
--- tenths
--- 12
--- decimal
--- input_
--- shows
--- far
--- traveled
--- bar
--- 22
--- 24
--- 25
--- piece
--- 10
--- pieces
```

Cluster 28:

```
--- image_object_groups_
--- area_target_contents_
--- plain_image_groups_
--- swf
--- piranhas
--- x_468
--- tank
--- fish
--- total_1
--- drag
--- total_12
--- on_3
--- count_3
--- answer
--- on_0
--- tenths
```

```
--- off_6
--- on_2
--- count_2
--- on_4
--- count_4
--- total_8
--- box
--- 10
--- total_9
--- total_6
--- off_3
--- number
--- correct
--- off_2
```

Cluster 29:

```
--- numberline_associations_
--- fraction_cblock_chains_
--- plain_image_groups_
--- lcm_sum_
--- sum_
--- total_1
--- swf
--- obj_name_object
--- yard
--- start
--- __as3_type_fraction
--- url_assets cms_wootmath_fractions_number_line_markers_start_marker
--- pos_value_0
--- pieces_1_8
--- left_165
--- pieces_1_6
--- drag
--- fraction_cblock_counts_
--- numerator_1
--- pieces_1_4
--- pieces_1_3
--- denominator_3
--- fraction_cblock_total_count_1
--- denominator_8
--- top_375
--- input_3
--- denominator_6
--- denominator_4
--- numerator_3
--- input_8
```

Cluster 30:

```
--- numberline_associations_
--- panda
--- plain_image_groups_
--- url_assets_cms_wootmath_fractions_number_line_objects_v2_panda
--- obj_name_object
--- mile
--- pos_value_0
--- total_1
--- swf
--- drag
--- answer
--- input_5
--- input_4
--- input_3
--- input_7
--- position_260
--- 25
--- pos_value_1
--- input_9
--- position_200
--- 17
--- 33
--- 34
--- position_550
--- 13
--- input_8
--- miles
--- bitmap_text_interp_
--- bitmap_text_inputs_
--- line
```

Cluster 31:

```
--- makes
--- statement
--- true
--- bitmap_text_interp_
--- bitmap_text_inputs_
--- number
--- enter
--- input_1
--- input_a_1
--- input_2
--- input_a_4
--- input_3
--- input_a_3
--- input_4
--- input_a_2
--- 10
```

```
--- input_a_5
--- input_5
--- input_a_6
--- 12
--- input_6
--- numbers
--- create
--- input_a_8
--- input_a_7
--- input_8
--- input_7
--- input_a_9
--- input_0
--- input_9
```

Cluster 32:

```
--- complete
--- sentence
--- addition
--- bitmap_text_inputs_
--- bitmap_text_interp_
--- problem_text_1_2
--- problem_text_1
--- problem_text_2
--- input_b_1
--- problem_text_3
--- input_a_1
--- input_a_2
--- answer
--- input_b_2
--- input_a_3
--- 1_6
--- 1_12
--- 1_8
--- 1_4
--- input_1
--- 1_10
--- 2_8
--- input_2
--- input_a_4
--- 2_6
--- input_b_3
--- 3_4
--- 4_6
--- input_a_5
--- 5_6
```

Cluster 33:

```
--- pieces_1_5
--- fraction_circle_groups_
--- chains_
--- denominator_5
--- lcm_sum_
--- sum_
--- fraction_circle_counts_
--- circle1_
--- __as3_type_fraction
--- unit1_
--- scale_0
--- fraction_circle_containment_
--- unit2_
--- pieces_1
--- 1_
--- fraction
--- unit_
--- object
--- scale_1
--- y_350
--- circle0_
--- circle
--- numerator_3
--- numerator_1
--- den_5
--- numerator_4
--- black
--- 1_1
--- left_270
--- numerator_5
```

Cluster 34:

```
--- input_a_1
--- bitmap_text_interp_
--- bitmap_text_inputs_
--- form
--- simplest
--- words
--- model_lbl_0
--- fraction_input_value_
--- enter
--- express
--- decimal
--- answer
--- tenths
--- input_a_2
--- fraction
--- model
```

```
--- 10
--- 2_4
--- input_a_3
--- input_b_6
--- input_a_7
--- 3_6
--- 2_8
--- input_a_5
--- 4_6
--- input_b_4
--- 2_6
--- input_b_3
--- input_a_4
--- input_a_9
```

Cluster 35:

```
--- pieces_1_9
--- fraction_circle_groups_
--- chains_
--- denominator_9
--- sum_
--- lcm_sum_
--- fraction_circle_counts_
--- __as3_type_fraction
--- 1_3_
--- fraction_cblock_chains_
--- fraction
--- circle1_
--- scale_1
--- fraction_circle_containment_
--- unit_
--- numerator_1
--- 1_
--- unit1_
--- whites
--- numerator_7
--- pieces_1
--- pieces_1_3
--- 1_1
--- x_300
--- numerator_9
--- scale_0
--- bar1_
--- 1_9_3
--- unit2_
--- brown
```

Cluster 36:

```

--- fraction_circle_groups_
--- 1_2_
--- pieces_1_2
--- fraction
--- lcm_sum_
--- sum_
--- chains_
--- pieces_1_4
--- denominator_2
--- fraction_circle_counts_
--- __as3_type_fraction
--- fraction_circleContainment_
--- numerator_1
--- unit1_
--- unit2_
--- 1_
--- scale_0
--- scale_1
--- y_300
--- pieces_1
--- numerator_2
--- x_512
--- left_0
--- half
--- right_180
--- 1_2_2
--- 1_4_2
--- fraction_circle_total_count_4
--- right_270
--- fraction_circle_total_count_3

```

Cluster 37:

```

--- whole_
--- num_2
--- greatest
--- enter
--- fraction_input_value_2_3
--- den_4
--- fraction
--- den_3
--- answer
--- fraction_input_value_2_4
--- fraction_input_value_3_4
--- num_3
--- den_7
--- greater
--- fractions
--- form

```

```
--- simplest
--- fraction_input_value_2_6
--- den_8
--- different
--- den_6
--- num_6
--- den_5
--- num_1
--- fraction_input_value_1_3
--- equal
--- smaller
--- den_15
--- fraction_input_value_1_4
--- num_5
```

Cluster 38:

```
--- fraction_cblock_chains_
--- pieces_1_5
--- lcm_sum_
--- sum_
--- denominator_5
--- bar1_
--- __as3_type_fraction
--- left_130
--- numerator_1
--- denominator_1
--- bar
--- right_820
--- fraction_cblock_counts_
--- top_248
--- object
--- fifth
--- black
--- numerator_3
--- 1_1
--- numerator_2
--- dragging
--- fraction_cblock_containment_
--- numerator_4
--- orange
--- pieces_1
--- model
--- 1_5_5
--- right_268
--- numerator_5
--- right_544
```

Cluster 39:

```
--- input_a_
--- 30
--- input_
--- correct
--- enter
--- 50
--- 100
--- 10
--- 20
--- 14
--- 60
--- 17
--- 80
--- 16
--- 13
--- 11
--- 24
--- 12
--- 52
--- 51
--- 42
--- 32
--- half
--- png
--- plain_image_groups_
--- answer
--- hundredths
--- statement
--- true
--- make
```

Cluster 40:

```
--- grid
--- model
--- answer
--- 10
--- 100
--- numbers
--- 11
--- 14
--- boxes
--- 13
--- 20
--- 15
--- 12
--- decimal
--- drag
--- use
```

```
--- shown
--- covering
--- pieces
--- hundredths
--- 22
--- 17
--- 16
--- fraction_circle_total_count_5
--- fraction_circle_total_count_7
--- fraction_circle_total_count_6
--- fraction_circle_total_count_9
--- fraction_circle_total_count_4
--- fraction_circle_total_count_3
--- fraction_circle_total_count_2
```

Cluster 41:

```
--- plain_image_groups_
--- total_1
--- swf
--- choose
--- comparison
--- correct
--- url_assets_cms_wootmath_fractions_number_line_mug_mug_half_01
--- answer
--- input_a_
--- input_
--- length
--- enter
--- url_assets_cms_wootmath_fractions_number_line_objects_v2_trex
--- hippo
--- url_assets_cms_wootmath_fractions_number_line_objects_v2_hippo
--- url_assets_cms_wootmath_fractions_number_line_objects_v2_panda
--- true
--- make
--- sentence
--- label
--- url_assets_cms_wootmath_fractions_number_line_markers_start_marker
--- drag
--- fraction_circle_groups_
--- fraction_circle_total_count_14
--- fraction_cblock_total_count_4
--- fraction_cblock_total_count_5
--- fraction_cblock_total_count_6
--- fraction_circle_total_count_2
--- fraction_circle_total_count_16
--- fraction_circle_total_count_15
```

Cluster 42:

```
--- numberline_associations_
--- obj_value_
--- label
--- yard
--- location
--- line
--- obj_name_eqn
--- number
--- correct
--- pos_value_1
--- fraction_cblock_chains_
--- drag
--- input_
--- obj_name_answer_text
--- lcm_sum_
--- sum_
--- answer
--- pos_value_0
--- pieces_1_4
--- __as3_type_fraction
--- position_400
--- position_450
--- miles
--- pieces_1_3
--- input_6
--- fraction_cblock_counts_
--- input_8
--- mile
--- input_7
--- numerator_1
```

Cluster 43:

```
--- numberline_associations_
--- plain_image_groups_
--- total_1
--- swf
--- start
--- obj_name_object
--- url_assets cms wootmath fractions number_line_markers_start_marker
--- pos_value_0
--- meter
--- shark
--- drag
--- beetle
--- input_12
--- 10
--- tenths
--- mile
```

```
--- input_11
--- thenswam
--- location
--- answer
--- final
--- yard
--- swam
--- obj_name_obj
--- pos_value_1
--- tenth
--- position_380
--- hundredths
--- input_6
--- input_
```

Cluster 44:

```
--- math
--- sentence
--- complete
--- drag
--- correct
--- tenths
--- answer
--- undefined
--- amounts
--- equally
--- people
--- express
--- object
--- cookies
--- bitmap_text_inputs_
--- bitmap_text_interp_
--- plain_image_groups_
--- numbers
--- input_1
--- input_4
--- pizzas
--- 3_6
--- foot
--- multiplication
--- 1_6
--- ant
--- input_a_4
--- boxes
--- 10
--- input_a_6
```

Cluster 45:

```
--- pieces_1_6
--- fraction_circle_groups_
--- chains_
--- lcm_sum_
--- sum_
--- fraction_circle_counts_
--- __as3_type_fraction
--- denominator_6
--- fraction_circle_containment_
--- piece_0_
--- fraction
--- unit1_
--- scale_0
--- 1_3_
--- scale_1
--- pieces_1_3
--- unit2_
--- circle1_
--- numerator_1
--- piece_1_
--- y_300
--- unit_
--- pieces_1
--- left_0
--- denominator_3
--- 1_2_
--- numerator_2
--- right_120
--- x_512
--- 1_1
```

Cluster 46:

```
--- write
--- used
--- divideboth
--- denominator
--- numerator
--- form
--- simplest
--- number
--- mult_d_2
--- enter
--- mult_n_2
--- divide
--- answer
--- 12
--- 15
--- 10
```

```
--- fraction_cblock_chains_
--- lcm_sum_
--- sum_
--- fraction_cblock_total_count_1
--- __as3_type_fraction
--- numerator_1
--- fraction_cblock_counts_
--- denominator_2
--- pieces_1_4
--- denominator_1
--- fraction_cblock_total_count_2
--- pieces_1_8
--- denominator_4
--- left_317
```

Cluster 47:

```
--- pieces_1_8
--- fraction_circle_groups_
--- chains_
--- sum_
--- lcm_sum_
--- fraction_circle_counts_
--- denominator_8
--- 1_2_
--- __as3_type_fraction
--- fraction_circle_containment_
--- fraction
--- unit1_
--- piece_0_
--- y_300
--- scale_0
--- circle1_
--- scale_1
--- unit2_
--- left_0
--- pieces_1
--- 1_8_4
--- numerator_1
--- piece_2_
--- piece_1_
--- numerator_4
--- x_512
--- unit_
--- 1_1
--- 1_
--- denominator_2
```

Cluster 48:

```
--- smallest
--- whole_
--- enter
--- fraction
--- den_12
--- num_1
--- num_2
--- den_10
--- answer
--- 12
--- 10
--- den_8
--- den_7
--- fraction_input_value_1_8
--- num_3
--- 15
--- num_4
--- common
--- den_3
--- fraction_input_value_2_3
--- den_
--- den_5
--- num_
--- denominator
--- decimal
--- den_6
--- den_4
--- box
--- num_5
--- input_
```

Cluster 49:

```
--- denominator
--- fractions
--- greater
--- bitmap_text_inputs_
--- bitmap_text_interp_
--- input_a_3
--- fraction_input_value_
--- bar
--- input_a_2
--- fraction
--- match
--- enter
--- shaded
--- object
--- shade
--- input_a_4
```

```
--- input_b_8
--- equivalent
--- shown
--- input_b_6
--- equal
--- answer
--- input_b_4
--- input_a_6
--- 1_3
--- 1_2
--- input_a_5
--- input_b_12
--- 1_4
--- input_a_1
```

Cluster 50:

```
--- fraction_cblock_chains_
--- sum_
--- lcm_sum_
--- pieces_1_5
--- __as3_type_fraction
--- denominator_5
--- numerator_1
--- denominator_1
--- fraction_cblock_counts_
--- left_80
--- pieces_1_10
--- numerator_3
--- numerator_2
--- unit2_
--- unit1_
--- right_770
--- numerator_4
--- pieces_1
--- fraction_cblockContainment_
--- bar1_
--- bar2_
--- left_90
--- fraction
--- right_780
--- denominator_10
--- model
--- numerator_5
--- 1_2
--- denominator_3
--- pieces_1_3
```

Cluster 51:

```
--- area_target_contents_
--- plain_image_groups_
--- y_118
--- x_468
--- total_1
--- swf
--- url_assets_objects_drag_and_drop_night_sky_night_sky
--- sky
--- stars
--- x_10
--- y_78
--- night
--- drag
--- count_3
--- count_2
--- count_4
--- chocolate
--- answer
--- pizza
--- fraction_circle_groups_
--- count_1
--- scale_0
--- equally
--- person
--- people
--- divide
--- box
--- pieces_1_4
--- pieces_1_2
--- total_2
```

Cluster 52:

```
--- plain_image_groups_
--- fraction_cblock_chains_
--- total_1
--- swf
--- lcm_sum_
--- sum_
--- __as3_type_fraction
--- traveled
--- url_assets_cms_wootmath_fractions_number_line_markers_start_marker
--- url_assets_cms_wootmath_fractions_number_line_markers_end_marker
--- numerator_1
--- fraction_cblock_counts_
--- far
--- left_96
--- pieces_1_3
--- pieces_1_4
```

```
--- pieces_1_10
--- denominator_3
--- figure
--- use
--- denominator_2
--- denominator_4
--- distance
--- pieces_1_2
--- answer
--- fraction_cblock_total_count_1
--- pieces
--- fraction_cblock_total_count_2
--- shows
--- whole_
```

Cluster 53:

```
--- object
--- grid
--- tenths
--- hundredths
--- model
--- decimal
--- answer
--- 19
--- 24
--- 13
--- 15
--- 11
--- 10
--- tenth
--- 12
--- 14
--- 16
--- 80
--- 60
--- 22
--- 17
--- 18
--- 20
--- 40
--- common
--- 25
--- 33
--- denominator
--- 32
--- 31
```

Cluster 54:

```
--- 12
--- half
--- answer
--- radio_group_problem_
--- ate
--- input_0
--- fraction
--- input_a_0
--- hundredths
--- arrange
--- boxes
--- greatest
--- object
--- fractions
--- 11
--- enter
--- drag
--- 10
--- piece
--- cake
--- amounts
--- bigger
--- model
--- bar
--- decimal
--- input_6
--- think
--- pizza
--- numbers
--- black
```

Cluster 55:

```
--- ran
--- numberline_associations_
--- mile
--- biked
--- total
--- obj_name_a_text
--- obj_value_a
--- distance
--- stopped
--- line
--- pos_value_1
--- number
--- miles
--- long
--- drag
--- input_12
```

```
--- run
--- blocks
--- answer
--- block
--- far
--- input_16
--- did
--- input_8
--- object
--- 75
--- express
--- position_400
--- whole_1
--- fraction_input_value_1
```

Cluster 56:

```
--- true
--- make
--- boxes
--- fractions
--- comparison
--- answer
--- drag
--- numbers
--- different
--- decimal
--- use
--- sentence
--- 24
--- pieces
--- using
--- enter
--- number
--- 12
--- tenths
--- statement
--- input_
--- 42
--- 10
--- 52
--- 51
--- 54
--- 63
--- 62
--- 55
--- 43
```

Cluster 57:

```
--- pieces_1_12
--- fraction_cblock_chains_
--- lcm_sum_
--- sum_
--- __as3_type_fraction
--- numerator_1
--- denominator_12
--- fraction_cblock_counts_
--- denominator_1
--- left_100
--- bar1_
--- denominator_2
--- bar2_
--- fraction
--- fraction_cblock_containment_
--- denominator_3
--- right_790
--- left_176
--- denominator_4
--- piece0_
--- pieces_1
--- top_300
--- 1_4_
--- numerator_3
--- 1_3_
--- pieces_1_4
--- 12
--- pieces_1_2
--- numerator_6
--- right_445
```

Cluster 58:

```
--- pieces_1_3
--- fraction_circle_groups_
--- chains_
--- lcm_sum_
--- sum_
--- denominator_3
--- fraction_circle_counts_
--- unit1_
--- __as3_type_fraction
--- scale_0
--- unit2_
--- 1_
--- fraction_circle_containment_
--- circle1_
--- fraction
--- pieces_1
```

```
--- numerator_1
--- circle
--- numerator_2
--- 1_3_3
--- y_300
--- scale_1
--- left_270
--- numerator_3
--- black
--- fraction_circle_total_count_4
--- browns
--- x_300
--- object
--- right_270
```

Cluster 59:

```
--- den_15
--- 15
--- whole_
--- smallest
--- enter
--- fraction
--- answer
--- smaller
--- 13
--- numerator
--- 11
--- num_11
--- num_2
--- greatest
--- num_1
--- denominator
--- greater
--- num_4
--- num_8
--- 12
--- num_7
--- num_3
--- missing
--- num_5
--- 14
--- 10
--- num_6
--- num_9
--- form
--- simplest
```

Cluster 60:

```
--- fraction_cblock_chains_
--- sum_
--- lcm_sum_
--- bar1_
--- __as3_type_fraction
--- numerator_1
--- left_130
--- denominator_1
--- bar
--- fraction_cblock_counts_
--- right_820
--- top_248
--- black
--- pieces_1_4
--- object
--- denominator_4
--- dragging
--- fraction_cblock_containment_
--- denominator_2
--- denominator_3
--- 1_1
--- numerator_2
--- pieces_1
--- pieces_1_3
--- denominator_7
--- fraction_cblock_total_count_2
--- model
--- left_60
--- pieces_1_7
--- piece
```

Cluster 61:

```
--- area_target_contents_
--- x_30
--- paint
--- url_atlas
--- __ratio_mixer_btn_square_text
--- png
--- plain_image_groups_
--- white
--- y_210
--- y_460
--- pots
--- green
--- count_2
--- count_1
--- total_1
--- shade
```

```
--- blue
--- count_3
--- y_400
--- box
--- answer
--- make
--- count_4
--- red
--- parts
--- drag
--- pink
--- whites
--- enter
--- shown
```

Cluster 62:

```
--- minutes
--- homework
--- takes
--- hours
--- math
--- object
--- hour
--- 20
--- 45
--- left
--- 30
--- 60
--- whole_2
--- fraction_input_value_2
--- answer
--- whole_1
--- fraction_input_value_1
--- num_1
--- 15
--- den_2
--- input_a_4
--- input_4
--- den_3
--- den_4
--- num_2
--- friends
--- does
--- 1_2
--- complete
--- input_2
```

Cluster 63:

```
--- decimals
--- order
--- arrange
--- greatest
--- input_
--- answer
--- 62
--- undefined
--- 58
--- 19
--- 22
--- 24
--- 75
--- 33
--- 81
--- 52
--- 16
--- 54
--- 83
--- 18
--- 44
--- 11
--- 17
--- 31
--- 32
--- 43
--- 34
--- 13
--- 85
--- 63
```

Cluster 64:

```
--- plain_image_groups_
--- total_1
--- swf
--- answer
--- url_assets cms wootmath fractions number_line_markers start_marker
--- length
--- enter
--- input_a_0
--- start
--- traveled
--- drag
--- shape
--- distance
--- whole_
--- far
--- box
```

```
--- label
--- url_assets_cms_wootmath_fractions_number_line_markers_end_marker
--- undefined
--- url_assets_cms_wootmath_fractions_number_line_objects_v2_bug_trail
--- boxes
--- url_assets_cms_wootmath_fractions_number_line_objects_v2_flying_trail
--- object
--- swam
--- num_1
--- url_assets_cms_wootmath_fractions_number_line_objects_v2_bubble_trail
--- input_12
--- board
--- den_4
--- url_assets_cms_wootmath_fractions_number_line_objects_v2_trex
```

Cluster 65:

```
--- fraction_circle_groups_
--- y_350
--- say
--- scale_1
--- fraction_circle_counts_
--- cover
--- piece
--- object
--- dark
--- x_750
--- fraction_circle_total_count_2
--- fraction_circle_total_count_1
--- yellow
--- x_250
--- brown
--- blue
--- x_300
--- pink
--- orange
--- 1_3_1
--- 1_5_1
--- reds
--- 1_4_1
--- 1_2_1
--- answer
--- pieces_1_3
--- pieces_1_2
--- red
--- pieces_1_5
--- pinks
```

Cluster 66:

```
--- fraction_input_value_1_2
--- den_2
--- num_1
--- whole_
--- 50
--- 100
--- enter
--- answer
--- form
--- simplest
--- fraction
--- smallest
--- fractions
--- different
--- plain_image_groups_
--- greater
--- express
--- 12
--- 10
--- greatest
--- total_1
--- swf
--- long
--- object
--- ate
--- longer
--- friends
--- pizza
--- left
--- 30
```

Cluster 67:

```
--- den_9
--- whole_
--- fraction
--- smallest
--- enter
--- answer
--- num_2
--- num_5
--- num_1
--- num_4
--- shaded
--- num_6
--- greater
--- num_8
--- num_3
--- smaller
```

```
--- greatest
--- num_7
--- cats
--- piranhas
--- rectangle
--- ate
--- divided
--- different
--- fractions
--- 15
--- 12
--- 10
--- num_9
--- parts
```

Cluster 68:

```
--- fraction_cblock_chains_
--- sum_
--- lcm_sum_
--- __as3_type_fraction
--- numerator_1
--- denominator_1
--- fraction_cblock_counts_
--- pieces_1
--- denominator_4
--- 1_
--- denominator_8
--- denominator_2
--- pieces_1_4
--- fraction
--- left_90
--- denominator_3
--- pieces_1_8
--- pieces_1_3
--- pieces_1_10
--- denominator_7
--- numerator_2
--- fraction_cblock_containment_
--- right_780
--- unit2_
--- pieces_1_6
--- pieces_1_2
--- left_80
--- left_125
--- pieces_1_7
--- top_225
```

Cluster 69:

```
--- shaded
--- parts
--- whole_
--- equal
--- fraction
--- rectangle
--- den_8
--- den_6
--- polygon
--- answer
--- flower
--- star
--- num_3
--- num_2
--- den_7
--- num_4
--- num_5
--- num_1
--- fraction_input_value_1_8
--- num_7
--- fraction_input_value_2_6
--- num_6
--- fraction_input_value_5_6
--- fraction_input_value_1_6
--- fraction_input_value_4_6
--- piranhas
--- fraction_input_value_3_6
--- den_5
--- den_4
--- fraction_input_value_3_4
```

Cluster 70:

```
--- radio_group_mc1_
--- radio_group_mc2_
--- plain_image_groups_
--- text_yes
--- choice_a
--- object
--- shapes
--- total_1
--- swf
--- shaded
--- text_no
--- choice_b
--- url_assets cms wootmath fractions_equal_parts_fourths_fourth_03
--- answer
--- fraction_circleContainment_
--- fraction_cblock_total_count_4
```

```
--- fraction_circle_total_count_15
--- fraction_cblock_total_count_18
--- fraction_cblock_total_count_2
--- fraction_circle_total_count_14
--- fraction_circle_total_count_13
--- fraction_circle_total_count_12
--- fraction_circle_total_count_11
--- fraction_cblock_total_count_3
--- fraction_circle_total_count_10
--- fraction_cblock_total_count_9
--- fraction_circle_total_count_1
--- fraction_circle_groups_
--- fraction_cblock_total_count_5
--- fraction_cblock_total_count_6
```

Cluster 71:

```
--- input_a_
--- input_
--- correct
--- enter
--- 20
--- 10
--- 40
--- 60
--- 80
--- 11
--- 24
--- 22
--- 12
--- 50
--- 100
--- 18
--- 31
--- 32
--- numbers
--- png
--- plain_image_groups_
--- 42
--- 19
--- answer
--- bitmap_text_interp_
--- bitmap_text_inputs_
--- 30
--- statement
--- true
--- make
```

Cluster 72:

```
--- fraction_cblock_chains_
--- pieces_1_8
--- lcm_sum_
--- sum_
--- __as3_type_fraction
--- denominator_8
--- numerator_1
--- bar1_
--- denominator_1
--- fraction_cblock_counts_
--- left_130
--- numerator_3
--- denominator_4
--- fraction
--- fraction_cblock_containment_
--- numerator_5
--- numerator_7
--- 1_4_
--- denominator_2
--- pieces_1
--- pieces_1_4
--- bar
--- right_820
--- numerator_8
--- left_176
--- left_100
--- top_248
--- 1_1
--- black
--- bar2_
```

Cluster 73:

```
--- 18
--- hundredths
--- grid
--- model
--- half
--- input_0
--- answer
--- input_a_0
--- 32
--- enter
--- total
--- object
--- 50
--- 12
--- decimal
--- eat
```

```
--- ate
--- did
--- pizza
--- 17
--- bigger
--- input_a_
--- input_
--- whole_
--- 16
--- divided
--- form
--- simplest
--- bitmap_text_interp_
--- bitmap_text_inputs_
```

Cluster 74:

```
--- form
--- simplest
--- enter
--- sum
--- difference
--- num_1
--- whole_2
--- fraction_input_value_2
--- whole_1
--- fraction_input_value_1
--- den_3
--- den_4
--- whole_3
--- fraction_input_value_3
--- den_10
--- den_2
--- num_3
--- 1_4
--- whole_
--- fraction_input_value_1_3
--- answer
--- den_6
--- 3_4
--- 1_2
--- num_2
--- 1_10
--- 1_3
--- 1_6
--- 2_3
--- mult_d_1_
```

Cluster 75:

```
--- rectangle
--- fraction_input_value_
--- shade
--- fraction
--- circle
--- match
--- shaded
--- 2_6
--- answer
--- equivalent
--- 2_8
--- object
--- 4_8
--- 12
--- bar
--- input_a_3
--- problem
--- input_a_2
--- radio_choice_b
--- 24
--- 10
--- input_a_6
--- 13
--- 16
--- input_12
--- input_8
--- 2_4
--- 15
--- input_a_4
--- 4_6
```

Cluster 76:

```
--- fraction_circle_groups_
--- scale_1
--- fraction_circle_counts_
--- chains_
--- fraction
--- lcm_sum_
--- sum_
--- pieces_1_6
--- pieces_1_4
--- pieces_1_10
--- 1_
--- pieces_1_3
--- pieces_1_12
--- __as3_type_fraction
--- pieces_1_5
--- pieces_1_8
```

```
--- pieces_1_2
--- pieces_1_15
--- numerator_1
--- pieces_1_9
--- scale_0
--- pieces_1_7
--- fraction_circleContainment_
--- x_512
--- pieces_1
--- y_400
--- 1_3_
--- answer
--- fraction_circle_total_count_3
--- piece
```

Cluster 77:

```
--- hour
--- makes
--- hours
--- make
--- object
--- complete
--- 10
--- multiplication
--- sentence
--- enter
--- answer
--- 24
--- line
--- 20
--- whole_
--- use
--- number
--- num_1
--- 25
--- den_5
--- 45
--- 55
--- fraction_input_value_1_5
--- 30
--- fraction_input_value_1_4
--- den_4
--- 40
--- 50
--- does
--- num_3
```

Cluster 78:

```
--- divided
--- fifths
--- yard
--- input_7
--- line
--- number
--- answer
--- input_a_2
--- sixths
--- input_8
--- input_a_3
--- input_a_4
--- num_1
--- input_a_6
--- whole_
--- den_12
--- input_a_1
--- 12
--- input_a_5
--- fraction_input_value_1_8
--- input_a_8
--- input_a_7
--- den_8
--- fraction_input_value_1_4
--- den_4
--- input_a_9
--- 16
--- input_a_
--- input_a_10
--- fraction_input_value_1_3
```

Cluster 79:

```
--- long
--- object
--- yards
--- bar
--- whole_1
--- fraction_input_value_1
--- foot
--- answer
--- mixed
--- plain_image_groups_
--- enter
--- number
--- board
--- den_6
--- whole_3
--- fraction_input_value_3
```

```
--- total_1
--- swf
--- den_4
--- den_8
--- num_5
--- den_3
--- miles
--- make
--- num_1
--- num_2
--- 5_6
--- den_5
--- cut
--- num_3
```

Cluster 80:

```
--- sum
--- bitmap_text_interp_
--- bitmap_text_inputs_
--- enter
--- equation_12
--- input_b_12
--- answer
--- equation_6
--- 15
--- 12
--- mult_d_2
--- mult_n_2
--- 10
--- mult_d_1_
--- mult_n_1_
--- input_a_7
--- 11
--- input_b_6
--- input_a_9
--- input_a_8
--- 2_3
--- input_a_6
--- 2_6
--- 14
--- input_a_10
--- 2_5
--- 2_4
--- input_a_5
--- 13
--- input_b_8
```

Cluster 81:

```
--- long
--- fraction_input_value_
--- yards
--- bar
--- fraction
--- whole_
--- bitmap_text_interp_
--- bitmap_text_inputs_
--- num_1
--- num_2
--- den_2
--- den_6
--- den_4
--- den_8
--- den_3
--- num_3
--- answer
--- input_a_6
--- input_a_4
--- input_a_3
--- input_a_2
--- input_a_8
--- num_4
--- den_1
--- num_5
--- num_6
--- den_5
--- num_7
--- den_7
--- input_a_1
```

Cluster 82:

```
--- comparison1
--- input_a_
--- input_
--- correct
--- enter
--- 50
--- 100
--- 22
--- 40
--- 60
--- 20
--- 24
--- 30
--- 12
--- 10
--- 11
```

```
--- 13
--- 25
--- 80
--- 51
--- 19
--- 16
--- 52
--- 18
--- 31
--- 15
--- 32
--- 14
--- 42
--- grid
```

Cluster 83:

```
--- png
--- plain_image_groups_
--- total_2
--- arrows
--- url_assets_cms_wootmath_fractions_ui_right_arrow
--- url_assets_cms_wootmath_fractions_ui_left_arrow
--- decimal
--- use
--- locations
--- points
--- correct
--- total_1
--- location
--- answer
--- total_3
--- url_atlas
--- input_16
--- input_a_
--- sum
--- enter
--- choose
--- comparison
--- statement
--- true
--- make
--- input_
--- order
--- greatest
--- drag
--- box
```

Cluster 84:

```
--- plain_image_groups_
--- swf
--- replace
--- total_6
--- make
--- answer
--- total_12
--- input_2_4
--- total_9
--- eat
--- total_8
--- input_2_2
--- 12
--- cookies
--- tank
--- url_assets_objects_singles_piranha
--- light
--- piranhas
--- fish
--- 16
--- input_2_3
--- oranges
--- total_1
--- png
--- friends
--- 50
--- total_2
--- total_3
--- shows
--- 45
```

Cluster 85:

```
--- did
--- number
--- shown
--- youranswer
--- line
--- form
--- simplest
--- miles
--- enter
--- mixed
--- bike
--- swim
--- far
--- walk
--- den_5
--- whole_2
```

```
--- fraction_input_value_2
--- run
--- whole_
--- whole_1
--- fraction_input_value_1
--- den_4
--- num_1
--- fraction
--- den_6
--- improper
--- answer
--- num_3
--- num_2
--- num_7
```

Cluster 86:

```
--- mug
--- hot
--- chocolate
--- plain_image_groups_
--- whole_
--- total_1
--- swf
--- num_1
--- fraction
--- den_4
--- url_assets_cms_wootmath_fractions_number_line_mug_mug_half_01
--- den_3
--- fraction_input_value_1_2
--- answer
--- den_2
--- fraction_input_value_1_3
--- fraction_input_value_1_4
--- num_2
--- fraction_input_value_2_4
--- fraction_input_value_3_4
--- num_3
--- fraction_input_value_2_3
--- den_1
--- den_5
--- num_4
--- den_
--- fraction_input_value_1_5
--- num_
--- fraction_input_value_
--- circle
```

Cluster 87:

```
--- numberline_associations_
--- plain_image_groups_
--- obj_name_object
--- mile
--- pos_value_0
--- total_1
--- swf
--- drag
--- input_5
--- answer
--- hippo
--- rex
--- url_assets_cms_wootmath_fractions_number_line_objects_v2_hippo
--- input_4
--- url_assets_cms_wootmath_fractions_number_line_objects_v2_trex
--- input_3
--- position_260
--- input_7
--- 25
--- input_9
--- position_200
--- 17
--- 75
--- png
--- pos_value_1
--- 33
--- 34
--- input_8
--- 67
--- position_550
```

Cluster 88:

```
--- missing
--- numerator
--- enter
--- bitmap_text_inputs_
--- bitmap_text_interp_
--- whole_
--- answer
--- input_1
--- input_a_1
--- 12
--- den_12
--- input_a_3
--- eqn_1_2
--- input_3
--- mult_d_2
--- mult_n_2
```

```
--- mult_d_1_
--- den_10
--- mult_n_1_
--- 15
--- 10
--- num_7
--- num_4
--- den_6
--- num_5
--- den_4
--- input_a_4
--- 1_2
--- input_4
--- 3_6
```

Cluster 89:

```
--- run
--- block
--- mile
--- does
--- wants
--- blocks
--- miles
--- answer
--- isabelle
--- num_1
--- input_a_2
--- object
--- den_2
--- whole_
--- mixed
--- input_a_6
--- input_a_4
--- 12
--- input_a_8
--- input_a_3
--- den_3
--- fraction_input_value_1_2
--- fraction_input_value_2
--- whole_2
--- enter
--- fraction_input_value_1_3
--- order
--- fraction_input_value_1
--- den_4
--- whole_1
```

Cluster 90:

```
--- fraction_input_value_
--- match
--- input_a_
--- choose
--- comparison
--- fraction
--- shade
--- correct
--- circle
--- bar
--- 1_3
--- flower
--- star
--- 1_4
--- 2_3
--- 3_4
--- 1_6
--- 2_4
--- 4_8
--- 3_6
--- 4_6
--- 3_5
--- 12
--- 2_5
--- 2_8
--- 6_8
--- 1_8
--- 2_6
--- 1_9
--- 5_6
```

Cluster 91:

```
--- numberline_associations_
--- plain_image_groups_
--- mile
--- walked
--- final
--- obj_name_obj
--- flew
--- total_1
--- swf
--- location
--- pos_value_0
--- url_assets cms wootmath fractions number_line_markers_start_marker
--- input_6
--- drag
--- input_8
--- input_4
```

```
--- position_550
--- answer
--- position_490
--- 75
--- 67
--- position_380
--- 83
--- 62
--- 63
--- position_260
--- 33
--- position_200
--- position_720
--- 25
```

Cluster 92:

```
--- fraction_input_value_1_6
--- den_6
--- num_1
--- whole_
--- answer
--- fraction
--- enter
--- plain_image_groups_
--- smallest
--- object
--- divided
--- form
--- simplest
--- circle
--- total_1
--- swf
--- pizza
--- greatest
--- 12
--- shaded
--- parts
--- write
--- difference
--- friends
--- model
--- left
--- equally
--- party
--- rectangle
--- far
```

Cluster 93:

```
--- numberline_associations_
--- line
--- location
--- number
--- pos_value_0
--- correct
--- label
--- drag
--- pos_value_1
--- divide
--- lengths
--- mile
--- labels
--- obj_value_0
--- obj_value_1
--- equal
--- obj_name_answer_text
--- obj_name_answer_text1
--- obj_name_answer_text2
--- answer
--- input_9
--- input_7
--- input_5
--- input_8
--- den_input_8
--- den_input_6
--- pos_value_
--- position_380
--- position_260
--- position_720
```

Cluster 94:

```
--- fraction_circle_groups_
--- circle1_1_
--- circle1_2_
--- fraction_circle_counts_
--- lcm_sum_
--- sum_
--- y_350
--- scale_1
--- chains_
--- __as3_type_fraction
--- pieces_1_12
--- object
--- numerator_1
--- x_750
--- pieces_1_6
--- fraction_circle_containment_
```

```
--- say
--- x_250
--- pieces_1_4
--- cover
--- piece
--- pieces_1_15
--- dark
--- pieces_1_8
--- left_270
--- pieces_1_10
--- blue
--- pieces_1_9
--- yellow
--- denominator_6
```

Cluster 95:

```
--- 10
--- den_10
--- boxes
--- greatest
--- fraction
--- arrange
--- fractions
--- whole_
--- answer
--- drag
--- num_7
--- smaller
--- greater
--- num_5
--- num_6
--- num_3
--- enter
--- num_9
--- num_2
--- num_1
--- num_8
--- num_4
--- piranhas
--- shaded
--- eat
--- purple
--- ate
--- did
--- bar
--- pizza
```

Cluster 96:

```
--- pieces_1_7
--- denominator_7
--- fraction_cblock_chains_
--- fraction_circle_groups_
--- lcm_sum_
--- sum_
--- __as3_type_fraction
--- bar1_
--- chains_
--- left_130
--- numerator_1
--- fraction_circle_counts_
--- denominator_1
--- unit1_
--- black
--- object
--- seventh
--- bar
--- pieces_1
--- numerator_5
--- 1_1
--- scale_0
--- fraction_cblock_counts_
--- circle1_
--- numerator_6
--- unit2_
--- fraction_circle_containment_
--- numerator_3
--- 1_
--- right_820
```

Cluster 97:

```
--- pieces_1_12
--- fraction_circle_groups_
--- chains_
--- sum_
--- lcm_sum_
--- fraction_circle_counts_
--- denominator_12
--- 1_2_
--- __as3_type_fraction
--- unit_
--- fraction
--- fraction_circle_containment_
--- scale_1
--- circle1_
--- 12
--- fraction_cblock_chains_
```

```
--- numerator_1
--- 1_12_6
--- y_350
--- scale_0
--- pieces_1
--- reds
--- x_300
--- y_300
--- 1_1
--- left_0
--- unit1_
--- numerator_6
--- pieces_1_4
--- unit2_
```

Cluster 98:

```
--- juice
--- pitcher
--- plain_image_groups_
--- orange
--- whole_
--- total_1
--- swf
--- fraction
--- num_1
--- answer
--- num_2
--- den_4
--- den_8
--- fraction_input_value_1_2
--- den_6
--- den_2
--- den_3
--- num_3
--- fraction_input_value_1_3
--- fraction_input_value_3_4
--- fraction_input_value_2_3
--- fraction_input_value_2_4
--- fraction_input_value_1_4
--- fraction_input_value_1_6
--- fraction_input_value_2_6
--- num_5
--- num_4
--- fraction_input_value_1_8
--- num_6
--- fraction_input_value_5_6
```

Cluster 99:

```

--- fraction_cblock_chains_
--- sum_
--- lcm_sum_
--- pieces_1_9
--- denominator_9
--- __as3_type_fraction
--- numerator_1
--- fraction_cblock_counts_
--- denominator_1
--- denominator_3
--- pieces_1_3
--- bar1_
--- numerator_2
--- left_90
--- fraction
--- pieces_1
--- fraction_cblock_containment_
--- left_80
--- 1_3_
--- top_225
--- 1_
--- left_130
--- bar2_
--- right_780
--- unit2_
--- numerator_3
--- numerator_4
--- bar
--- 1_9_6
--- 1_9_3

```

```

In [31]: df3['cluster_100'] = km.labels_

In [32]: df3['trait_1'] = df3['behavioral_traits'].apply(lambda x : x if type(x) is float else '')

In [33]: df3['trait_1'] = df3['behavioral_traits'].apply(lambda x : x[0]
                                                     if type(x) != float and len(x) > 0 else '')

In [34]: df3['trait_2'] = df3['behavioral_traits'].apply(lambda x : x[1]
                                                     if type(x) != float and len(x) > 1 else '')

In [35]: df_trait_1 = df3.groupby(['cluster_100', 'trait_1']).size().unstack(fill_value=0)
        df_trait_2 = df3.groupby(['cluster_100', 'trait_2']).size().unstack(fill_value=0)

In [36]: df_cluster_100 = df3.groupby('cluster_100')

In [37]: df_trait_1.index.rename('cluster_100', inplace=True)
        df_trait_2.index.rename('cluster_100', inplace=True)

```

```
for column in df_trait_1.columns:  
    if column in df_trait_2.columns:  
        df_trait_1[column] = df_trait_1[column] + df_trait_2[column]  
        df_trait_2.drop(column, axis=1, inplace=True)  
df_traits = pd.concat([df_trait_1, df_trait_2], axis=1)
```

In [38]: df_traits = df_traits.drop('None', axis=1)

In [39]: #df_traits_norm = (df_traits - df_traits.mean()) / (df_traits.max() - df_traits.min())
df_traits_norm = (df_traits / (df_traits.sum())))

In [40]: fig = plt.figure(figsize=(18.5, 16))
cmap = sns.cubehelix_palette(light=.95, as_cmap=True)
sns.heatmap(df_traits_norm, cmap=cmap, linewidths=.5)

```
#sns.heatmap(df_traits_norm, cmap="YlGnBu", linewidths=.5)
```

Out[40]: <matplotlib.axes._subplots.AxesSubplot at 0x7f770f795ef0>

