

Data Management and Exploratory Data Analysis

Buisness understanding

Business objectives

This report is focusing on Learning Analytics a fast developing domain of Data Science. In Learning Analytics organizations can extract context and better understanding of their programs. The goal is to derive suitable business results while improving employee productivity. The discoveries made could allow learning organizations to pick and choose learning models that works best, resulting to their organizations increase profit while lowering the time spent in developing the learning material. The organization in question provides an online course on cyber security, they have conducted 7 runs for this course. Further discussion on the course as a whole and differences between some of the runs will take place. The main goal is to produce findings derived from the data collected as well as further investigation on some of the most noticeable and interesting topics.

Assess situation

Learning Analytics refers to the collection and analysis of data about learners and their environments. Therefore, it is significant to create tools that provide and in depth understanding of the learners background undertaking the course. The scope of this analysis is improve the learning outcomes of the course both as a business standpoint and how its best received by the learners.

Determining data mining goals

In educational data mining it is important to classify learner performance and engagement. Furthermore, it is important to assess the material provided and the levels of engagement their provided. Some of the data mining goals at this stage are:

1. Learner background information.
2. Extraction of learner course completion across all runs.
3. Assessing the course material that provide a sense of performance.
4. Analysis on the data that provide further context in terms of learner engagement.
5. Various useful information extracted by the data mining process

In addition, a successful Data Mining process will be derived by:

- The reliability of the data.
- The importance of the results in terms of context, clarity and usefulness.
- The reliability of the processes conducted to extract results.
- The appropriate method used to provide a coherent discussion,

Project plan

The tools and techniques that are going to be used include Git version control, ProjectTemplate for R and RMarkdown. Git version control is a system that allows to keep track the changes made to the code over time. As such, collaboration is made possible because specific changes on the work are tracked and tagged by various contributors. The work for this project will be conducted by the author of this report, allowing for further expansion of the work with other collaborators in the future. ProjectTemplate in R allows for the automation of new statistical analysis projects. In addition, it provides a directory structure that automate data loading, preprocessing, library importing and testing. Finally, RMarkdown is a versatile open source markup language and can be used to format plain text while enabling the user to directly post their work on web pages if they must.

The project plan consists of the tools and techniques mentioned above to dwell into the data provided from the organization and produce a coherent structured report. The project plan includes the data understanding divided by some appropriate exploration and discussions. Next, is data preparation where the cleaning and construction of the data will take place. Finally, the modelling where in depth analysis will commence. The project plan will be layed out in detail in the next chapters of this report.

Data Understanding

Collection of initial data

The data are collected and loaded in the ProjectTemplate environment which has been set as a working directory using Git Bash. With the data loaded comes 7 pdf files containing the format of the material of each run commenced.

Data Description

The data that will be utilized consists of 53 csv files. The runs does not share the same number of csv files it noticeable that are inclusions and exclusions when each run commenced. This will be further explored in the data exploration.

The distinct csv files across all runs are as follows:

1. Archetype Survey responses
2. Enrollments
3. Leaving survey responses
4. Question responses
5. Step Activity
6. Weekly sentiment survey responses
7. Team members
8. Video stats

Decription of the data sets content

The archetype data set consist of the learner and an archetype answer regarding their general behavior. The enrollment data set consists of enrolled learners and 13 variables that provide numerous information such as enroll dates, fully completion dates, gender and more. Leaving survey responses includes of course the reason the learners gave for abandoning the course. The question responses data set consists of detailed learner performance regarding quizzes provided throughout the course. The step activity includes step progression for each week as well as started and completion dates for each step in the course. The weekly sentiment responses include weekly feedback from the learners regarding weekly progress. The team members data set

consists of description regarding the roles of the teaching team. Lastly, The video stats data set consist of various statistics regarding the video material on the course for example views, percentages watched, devices, geolocation and more.

Data exploration

By exploring the data several questions surfaced regarding some data sets. The data sets that was deemed appropriate for the outlined goals and business objectives includes the enrollment, question responses, step activity, video stats, leaving survey and weekly survey responses.

Enrollement data set (Run 1)

The enrollment data set consists of the learners as our observations number and each learner has 13 variables.

```
head(cyber.security.1_enrolments)

## # A tibble: 6 x 13
##   learner_id enrolled_at unenrolled_at role fully_participa~ purchased_state~
##   <chr>         <chr>         <chr>         <chr> <chr>         <chr>
## 1 160d6600-e~ 2016-08-10 ~ ""          lear~ ""          ""
## 2 4dc22fed-6~ 2016-05-24 ~ "2018-10-30 ~ lear~ ""          ""
## 3 ecdd37db-0~ 2016-05-19 ~ ""          lear~ "2016-09-22 16:~ ""
## 4 988964c9-7~ 2016-05-19 ~ ""          lear~ ""          ""
## 5 f1493366-1~ 2016-09-19 ~ ""          lear~ ""          ""
## 6 25cc3b46-a~ 2016-08-30 ~ ""          lear~ "2016-10-25 12:~ ""
## # ... with 7 more variables: gender <chr>, country <chr>, age_range <chr>,
## #   highest_education_level <chr>, employment_status <chr>,
## #   employment_area <chr>, detected_country <chr>
```

All 13 variable are stored as characters it noticeable that numerous rows are empty and some are stored as Unknown.

Question response data set (Run 1)

The question response data set consists of the learners as our observations number and for each learner there are 10 variables

```
head(cyber.security.1_question.response)

## # A tibble: 6 x 9
##   learner_id quiz_question question_type week_number step_number question_number
##   <chr>         <chr>         <chr>         <int>         <int>         <int>
## 1 77454a73~~ 1.7.1          MultipleChoi~      1             7             1
## 2 77454a73~~ 1.7.1          MultipleChoi~      1             7             1
## 3 a4fa6f89~~ 1.7.1          MultipleChoi~      1             7             1
## 4 a4fa6f89~~ 1.7.1          MultipleChoi~      1             7             1
## 5 a4fa6f89~~ 1.7.1          MultipleChoi~      1             7             1
## 6 f27eec8c~~ 1.7.1          MultipleChoi~      1             7             1
## # ... with 3 more variables: response <chr>, submitted_at <chr>, correct <chr>
```

Some variables are stored as characters namely learner_id, quiz_question, question_type response, submitted_at, correct. The rest are stored as integers except cloze_response that is logical and is filled with NAs. It is advisable to further investigate regarding inconsistencies.

Step activity data set (Run 1)

The step activity data set consists 143092 observations with 6 variables.

```
head(cyber.security.1_step.activity)
```

```
## # A tibble: 6 x 6
##   learner_id      step week_number step_number first_visited_at last_completed_~
##   <chr>          <dbl>      <int>      <int> <chr>          <chr>
## 1 77454a73-6b8~    1.1          1          1 2016-08-02 13:45~ ""
## 2 c1a75ae7-c76~    1.1          1          1 2016-08-02 15:40~ ""
## 3 a4fa6f89-a59~    1.1          1          1 2016-08-03 07:14~ ""
## 4 60b56cea-ad2~    1.1          1          1 2016-08-03 08:45~ "2016-08-03 08:~
## 5 05a815ce-3c4~    1.1          1          1 2016-08-03 13:24~ "2016-08-03 13:~
## 6 5553e67a-178~    1.1          1          1 2016-08-03 14:49~ "2016-08-04 15:~
```

Some variables are stored as characters namely learner_id, first_visited_at and last_completed_at the others are stored as integers except the step variable which is double.

Video stats data set (Run 3)

The video stats data set consists of 13 observation which refer to the video step position over the 3 weeks of the course and 28 variables. It's important to mention that the video stats data is not present in the first 2 runs.

```
head(cyber.security.3_video.stats)
```

```
## # A tibble: 6 x 28
##   step_position title                video_duration total_views total_downloads
##   <dbl> <chr>                <int>      <int>      <int>
## 1 1.1 Welcome to the course          99      1659      113
## 2 1.14 Why would anyone wan~       362       910       77
## 3 1.17 Preserving privacy i~       241       723       63
## 4 1.19 Staying safe online:~       348       755       62
## 5 1.5 Privacy online and o~       281      1248      100
## 6 2.1 Welcome to Week 2: p~        37       694       48
## # ... with 23 more variables: total_caption_views <int>,
## #   total_transcript_views <int>, viewed_hd <int>, viewed_five_percent <dbl>,
## #   viewed_ten_percent <dbl>, viewed_twentyfive_percent <dbl>,
## #   viewed_fifty_percent <dbl>, viewed_seventyfive_percent <dbl>,
## #   viewed_ninetyfive_percent <dbl>, viewed_onehundred_percent <dbl>,
## #   console_device_percentage <dbl>, desktop_device_percentage <dbl>,
## #   mobile_device_percentage <dbl>, tv_device_percentage <dbl>, ...
```

In the stat video we have variables stored as characters for the description of the videos, integers for counts and doubles for percentages.

Leaving survey responses (Run 5)

In the leaving survey response data set there are 174 learners with 8 variables.

```
head(cyber.security.5_leaving.survey.responses)
```

```
## # A tibble: 6 x 8
##       id learner_id   left_at leaving_reason last_completed_~ last_completed_~
##   <int> <chr>         <chr>    <chr>          <chr>              <dbl>
## 1 34003 8853543d-b9~ 2018-01~ I prefer not to~ ""                NA
## 2 38604 b170480c-7e~ 2018-02~ The course requ~ ""                NA
## 3 39016 92b8485e-b2~ 2018-02~ Other           ""                NA
## 4 39241 f4cae359-09~ 2018-02~ Other           ""                NA
## 5 39604 3429e915-a6~ 2018-02~ I prefer not to~ ""                NA
## 6 39657 a04b5f29-c2~ 2018-02~ Other           "2018-02-05 18:~ 1.2
## # ... with 2 more variables: last_completed_week_number <int>,
## #   last_completed_step_number <int>
```

By reviewing the data it is noticeable that learners that left the course are assigned new IDs regarding their leaving survey that are stored as integers. Furthermore, The last_completed step variables are stored as doubles while the last_completed_step_number are stored as integers. NAs can be spotted instantly further investigation will be required to assess the quality of the set.

Weekly survey responses data set (Run 6)

The weekly survey responses consist of 80 observations (learners) and 5 variables.

```
head(cyber.security.6_weekly.sentiment.survey.responses)
```

```
## # A tibble: 6 x 5
##       id responded_at          week_number experience_rating reason
##   <int> <chr>              <int>          <int> <chr>
## 1 16810 2018-06-11 18:28:04 UTC           1           3 ""
## 2 17388 2018-06-12 16:38:12 UTC           2           3 "It was good i ha~
## 3 17505 2018-06-12 20:24:38 UTC           2           3 "Nice Content !!"
## 4 17807 2018-06-13 12:05:35 UTC           1           3 ""
## 5 17819 2018-06-13 12:25:05 UTC           1           3 ""
## 6 18277 2018-06-14 10:31:48 UTC           1           3 ""
```

Similarly with the leaving responses they are assigned a survey ID, variables are stored as characters for the responded_at and the reason. The week_number and the experience_rating are stored as integers. It noticeable that some responses are missing for rating reason.

Verification of data quality

From the exploration in most data sets inconsistencies were noticed. Specifically, same type of variables where stored as different types, multiple empty rows where discovered, some rows where labeled Unknown. In addition, multiple data sets contain NAs, some columns were empty and in some of the responses surveys the characters contained symbols.

This report is going to cover specific topics and will be using a portion of the data sets available to explore and perform an in depth analysis. In the chapter data preparation will commence. After the selection of relevant data sets and rationale for inclusion and exclusion, the cleaning process will be documented where is applicable.

Data preparation

Selection of data

In this chapter an explanation will be given for the selection of the data that was previously discussed in data exploration. Each data set will be discussed and goals will be outlined for the production of the analysis. Furthermore, steps taken for cleaning, construction, integration and reformation will be discussed. It is important to state that the data preparation takes into account all the goals and methods outlined above. Specifically, general statistics, engagement, performance and various elements that will be derived from the analysis.

Enrollment

In the enrollment data set it is possible to extract a count of the people enrolled and their background information. In addition, we can calculate the percentage of the learners that fully participated in the course for the each run. This will show a scale of popularity among the runs and completion rates. Also some generic statistics about the learners.

Analysis goals:

1. Learners information
2. Course Engagement rates

Questions responses

The question response data set contains variables regarding quiz performance for each learner. Quizzes are a satisfactory way to access learner performance regarding the teaching material provided across 3 weeks for each run where applicable.

Analysis goals:

1. Success rate for every quiz.
2. Success rate based on each week.
3. Correlation regarding the material and failure rate regarding the material.

Step activity

Step activity is particularly useful data set because it contains details about each step across the three weeks of the course. It is possible to derive results that would provide vital information on the teaching material and the reception it received from the learners.

Analysis goals:

1. Time it took learners to complete each week.
2. Percentage of learners that completed every step.
3. Percentage of learners that completed each each week.
- 4 Completion ration for each step.
4. Most popular step type discussion.

Video stats

The video stats data set will enable the analysis to dwell deeper into this specific step type in order to get some context and some statistics of how well this step type was received by the learners as well as how it was conducted by the teaching team. Several assumptions could be taken beforehand that will be discussed in the analysis section.

Analysis goals:

1. Percentages of video views for each step.
2. Percentages of viewers filtered by device utilized
3. Percentages of viewers from each continent.

Question about leaving survey

This data set will be used to provide context for the discussion of the results if its applicable.

Analysis goals:

1. Categorizing leaving reasons and allocation of learners
2. Comparison with step analysis results to derive some context in terms of steps quality.

Questions about weekly survey

Similarly with the leaving survey this data set will be utilized for context if the findings are relevant.

Analysis goals:

1. Categorizing experience rating for steps outlined.

Data cleaning and data construction

###Enrollement cleaning

By checking for NAs in the enrollment data set it returns 13 NAs.By running the code:

```
cyber.security.1_enrolments= cyber.security.1_enrolments[rowSums(is.na(cyber.security.1_enrolments)) ==  
sum(is.na(cyber.security.1_enrolments))
```

```
## [1] 0
```

All NAs from the data set were omitted. in addition where applicable its possible to remove only rows that are fully NA using:

```
cyber.security.1_enrolments[rowSums(is.na(cyber.security.1_enrolments)) != ncol(cyber.security.1_enrolments)]
```

```
## # A tibble: 14,382 x 13  
##   learner_id enrolled_at unenrolled_at role fully_participa~ purchased_state~  
##   <chr>      <chr>      <chr>      <chr> <chr>      <chr>  
## 1 160d6600-e~ 2016-08-10~ ""      lear~ ""      ""  
## 2 4dc22fed-6~ 2016-05-24~ "2018-10-30 ~ lear~ ""      ""  
## 3 ecdd37db-0~ 2016-05-19~ ""      lear~ "2016-09-22 16:~ ""
```

```
## 4 988964c9-7~ 2016-05-19~ ""          lear~ ""          ""
## 5 f1493366-1~ 2016-09-19~ ""          lear~ ""          ""
## 6 25cc3b46-a~ 2016-08-30~ ""          lear~ "2016-10-25 12:~ ""
## 7 9c23a086-f~ 2016-06-22~ ""          lear~ "2016-10-10 11:~ ""
## 8 8851dc49-0~ 2016-08-07~ ""          lear~ "2018-10-17 18:~ ""
## 9 a59b0a12-a~ 2016-08-02~ "2018-10-17 ~ lear~ ""          ""
## 10 198c1017-5~ 2016-09-09~ ""          lear~ ""          ""
## # ... with 14,372 more rows, and 7 more variables: gender <chr>, country <chr>,
## #   age_range <chr>, highest_education_level <chr>, employment_status <chr>,
## #   employment_area <chr>, detected_country <chr>
```

Next checking for duplicates in the learner_id column:

```
cyber.security.1_enrolments$learner_id[duplicated(cyber.security.1_enrolments$learner_id)]
```

```
## character(0)
```

Enrolment data constuction for analysis

For the enrollment a new data frame is constructed containing the learners that fully participated in the course. Furthermore, this new subset is filtered by gender, education and employment status. Lastly, the same filters are applied in the full data set.

Question response cleaning

Firstly the empty cloze_response column is removed. Then we check for NAs it appears there are none:

```
sum(is.na(cyber.security.1_question.response))
```

```
## [1] 0
```

QQuestion response data constuction for analysis

For the question response data set 3 data frames are constructed filtered by the correct answers for the questions for each week respectively. This will later utilized to compare performance in terms of success. Furthermore, the worst performing week will be annualized further.

Step activity