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# Analytic Workflow and Managing and Cleaning Data

## Week 02-BEM2031

Term2: 2024/25

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# Today:

- Analyse and identify the components of a **data pipeline** or **analytic workflow**
- List the different stages of **data cleaning** and model development
- Look at potential **issues with data** and how to address these issues

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## Advantages:

Large community of resources

Free and open source with a large number of statistics-related libraries

Excellent visualisation and analysis tools

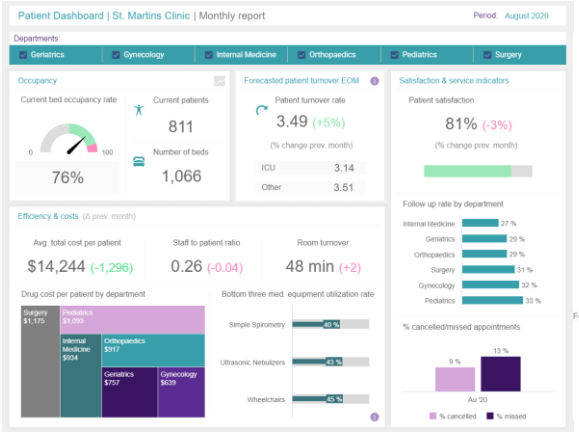
## Disadvantages:

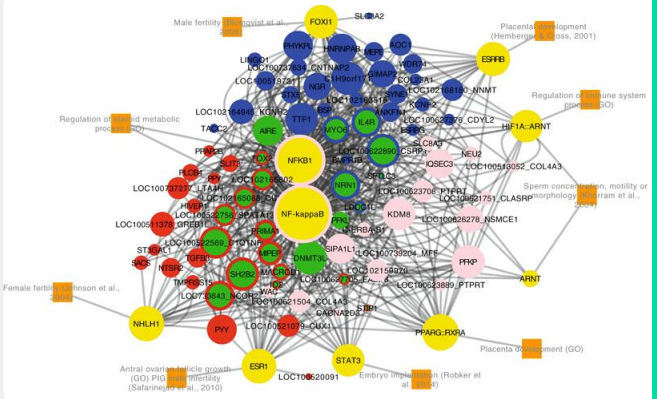
Speed and memory management

# Why R?

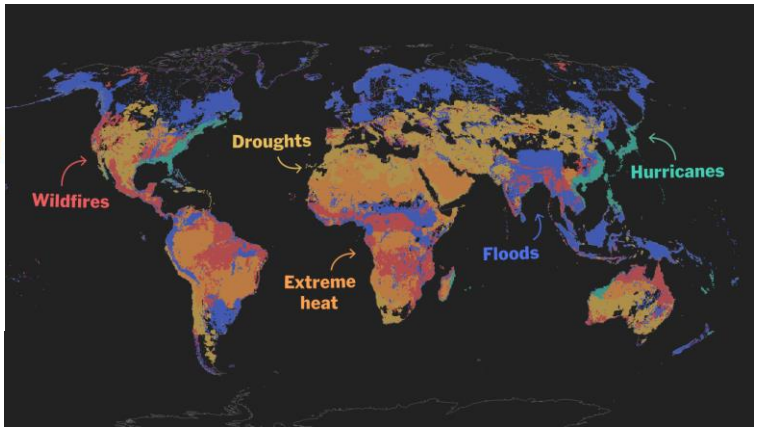
"Knowledge of programming fundamentals certainly helps when adding R to your toolbox, but I wouldn't say it's required to get started.

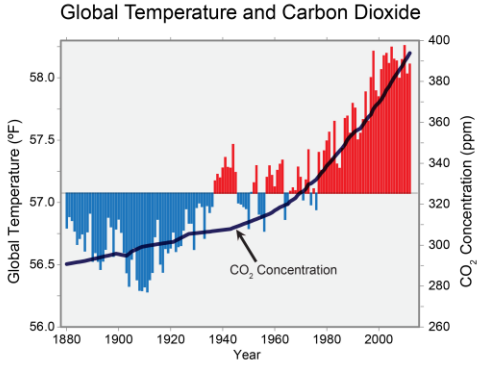
**R is best suited for people that have data-oriented problems they're trying to solve, regardless of their programming aptitude."**



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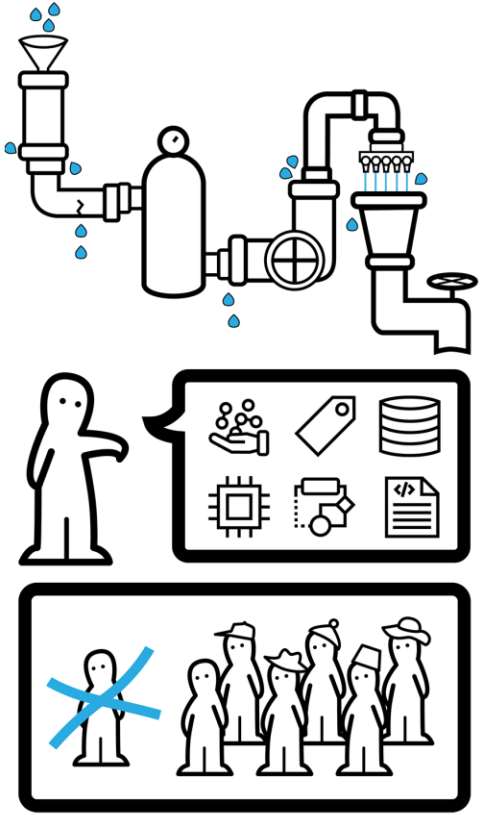
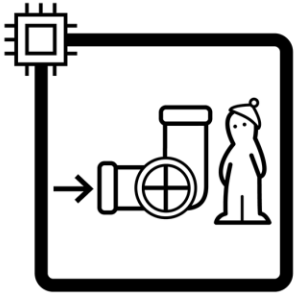
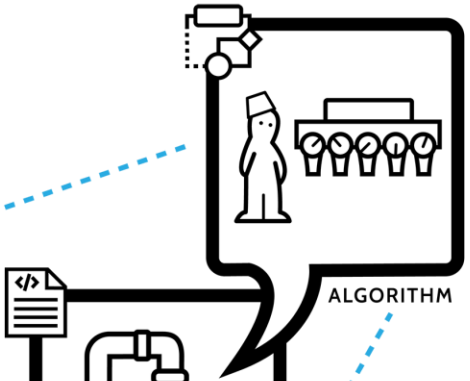
# DATA PIPELINE



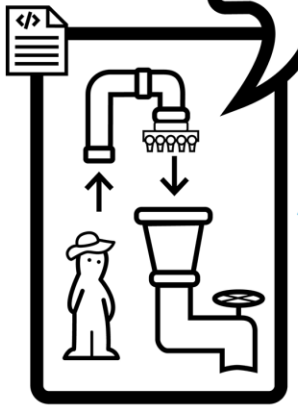
DATA COLLECTION



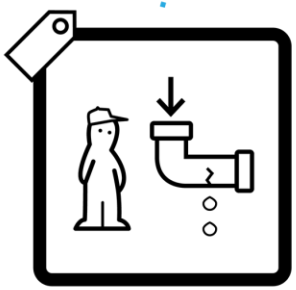
PROCESSING SUBSTRATE



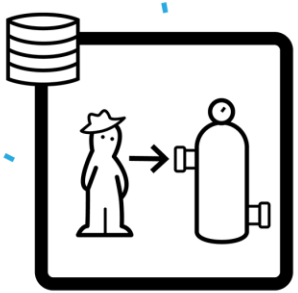
ALGORITHM



CODE

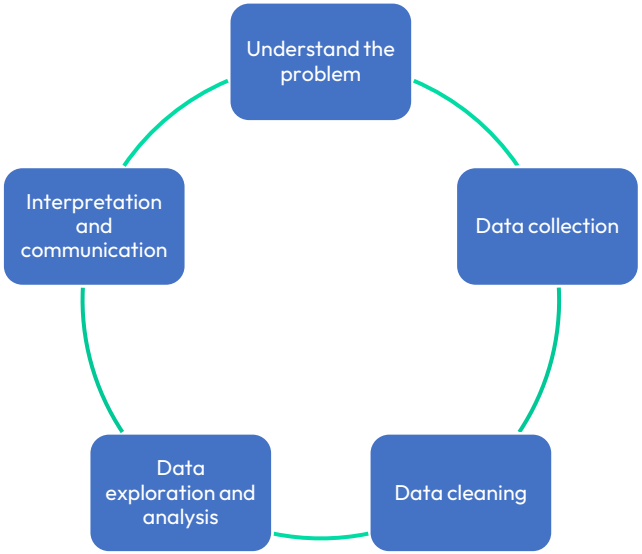


METADATA & CLEANING



STORAGE & RETRIEVAL ARCHITECTURE

OUTPUT




- **Problem definition:** Identifying and understanding business problem or opportunity
- **Data collection:** Gathering and understanding the necessary data from various sources
- **Data Cleaning and Preprocessing**: Refining the data to ensure quality and relevance
- **Data Exploration and Analysis:** Investigating the data for patterns and insights
- **Model building:** Developing descriptive/predictive/prescriptive models
- **Validation and testing:** Assessing the model's performance and accuracy
- **Interpretation and communication**
- **Deployment:** Implementing the model in a real-world setting (or further iteration – back round the loop)

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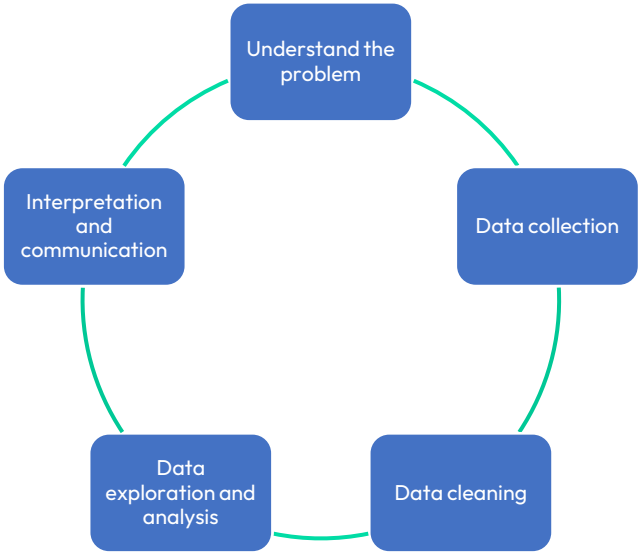


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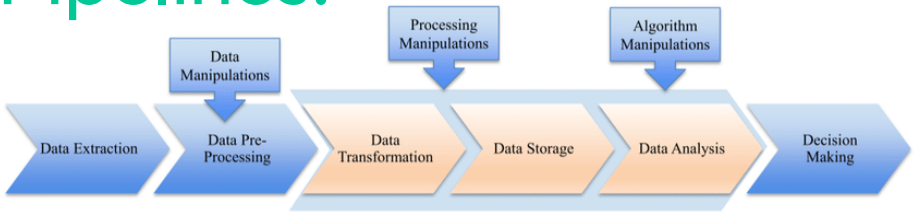
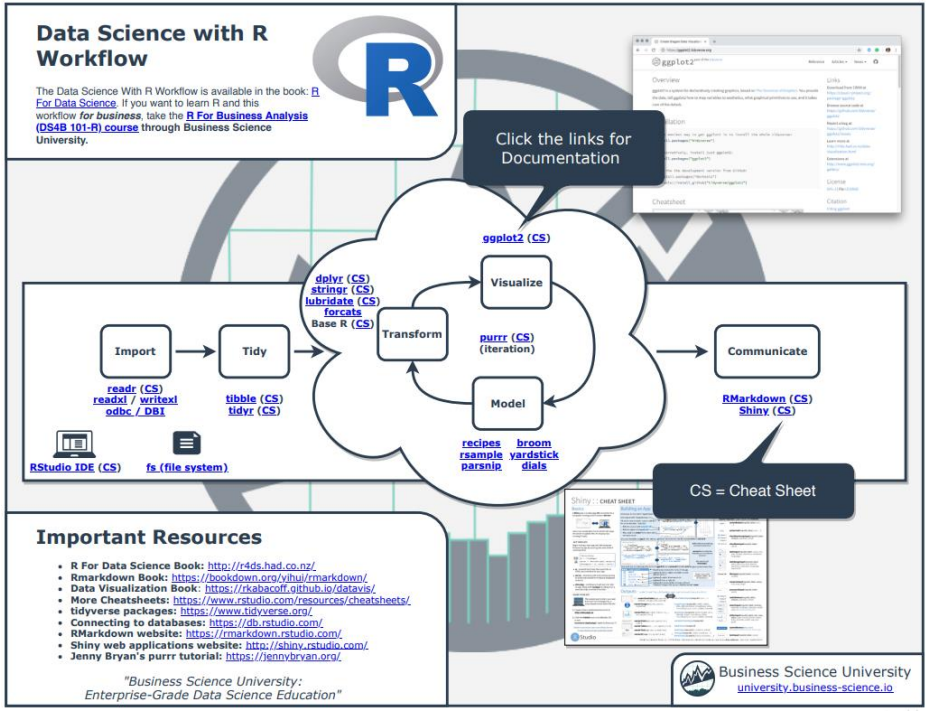
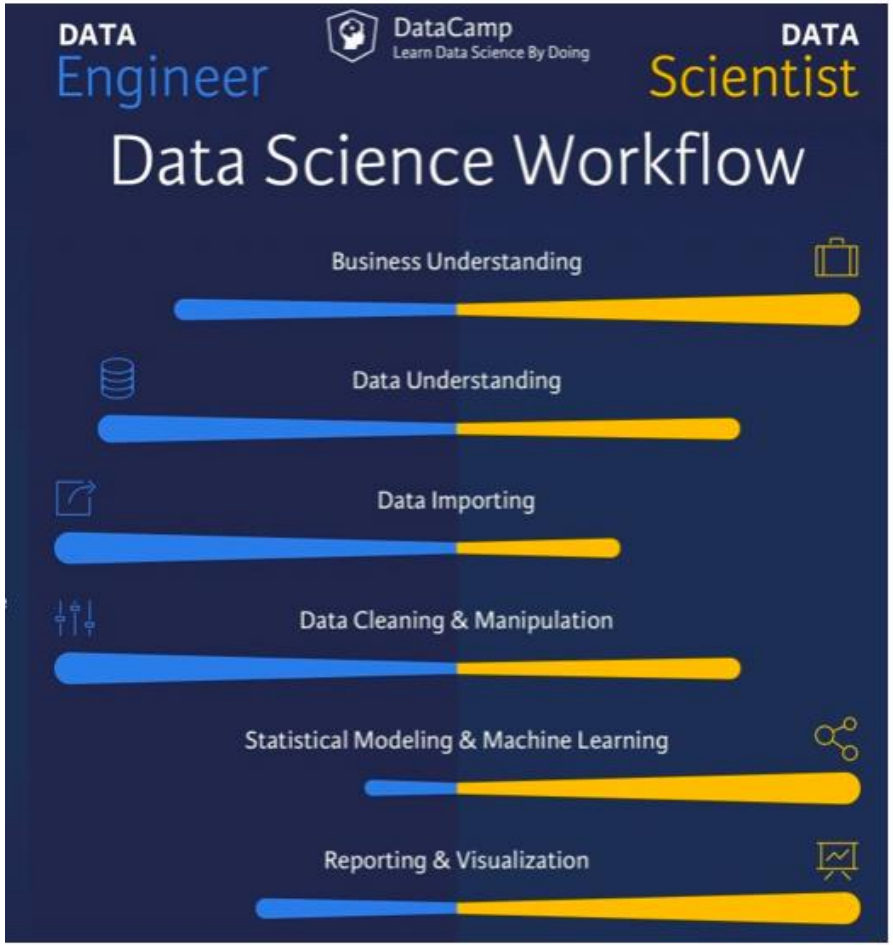
# Pipelines:


Data Manipulations
Processing Manipulations
Algorithm Manipulations
Data Extraction
Data Pre-Processing
Data Transformation
Data Storage
Data Analysis
Decision Making

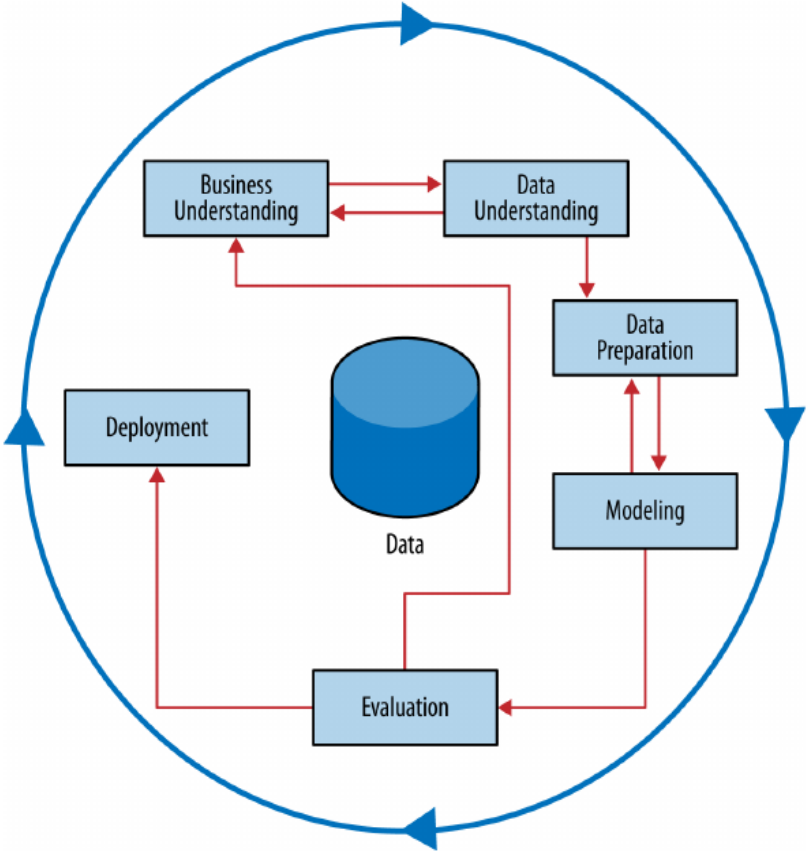

Data Science with R Workflow
The Data Science With R Workflow is available in the book: R For Data Science. If you want to learn R and this workflow for business, take the R For Business Analysis (DS4B 101-R) course through Business Science University.
Click the links for Documentation
ggplot2 (CS)
dplyr (CS)
stringr (CS)
lubridate (CS)
forcats
Base R (CS)
Visualize
Transform
purrr (CS)
(iteration)
Model
Import
Tidy
Communicate
readr (CS)
readxl / writexl
odbc / DBI
tibble (CS)
tidyr (CS)
RMarkdown (CS)
Shiny (CS)
RStudio IDE (CS)
fs (file system)
recipes
rsample
parsnip
broom
yardstick
dials
CS = Cheat Sheet
Important Resources
R For Data Science Book: http://r4ds.had.co.nz/
Rmarkdown Book: https://bookdown.org/yihui/rmarkdown/
Data Visualization Book: https://rkabacoff.github.io/datavis/
More Cheatsheets: https://www.rstudio.com/resources/cheatsheets/
tidyverse packages: https://www.tidyverse.org/
Connecting to databases: https://db.rstudio.com/
RMarkdown website: https://rmarkdown.rstudio.com/
Shiny web applications website: http://shiny.rstudio.com/
Jenny Bryan's purrr tutorial: https://jennybryan.org/
"Business Science University:
Enterprise-Grade Data Science Education"
Business Science University
university.business-science.io


DATA Engineer
DataCamp
Learn Data Science By Doing
DATA Scientist
Data Science Workflow
Business Understanding
Data Understanding
Data Importing
Data Cleaning & Manipulation
Statistical Modeling & Machine Learning
Reporting & Visualization

# CRISP-DM

## Cross Industry Standard Process for Data Mining - **CRISP-DM**

- Business Understanding
- Data Understanding
- Data Preparation
- Modelling
- Evaluation
- Deployment




Chapman, P., Clinton, J., Kerber, R., Khabaza, T., Reinartz, T., Shearer, C., & Wirth, R. (2000). CRISP-DM 1.0: Step-by-step data mining guide. SPSS inc, 9(13), 1-73 CRISPMWP-1104-1C.qxd (exeter.ac.uk)

Schröer, C., Kruse, F., & Gómez, J. M. (2021). A systematic literature review on applying CRISP-DM process model. *Procedia Computer Science*, *181*, 526-534.

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# CRISP-DM

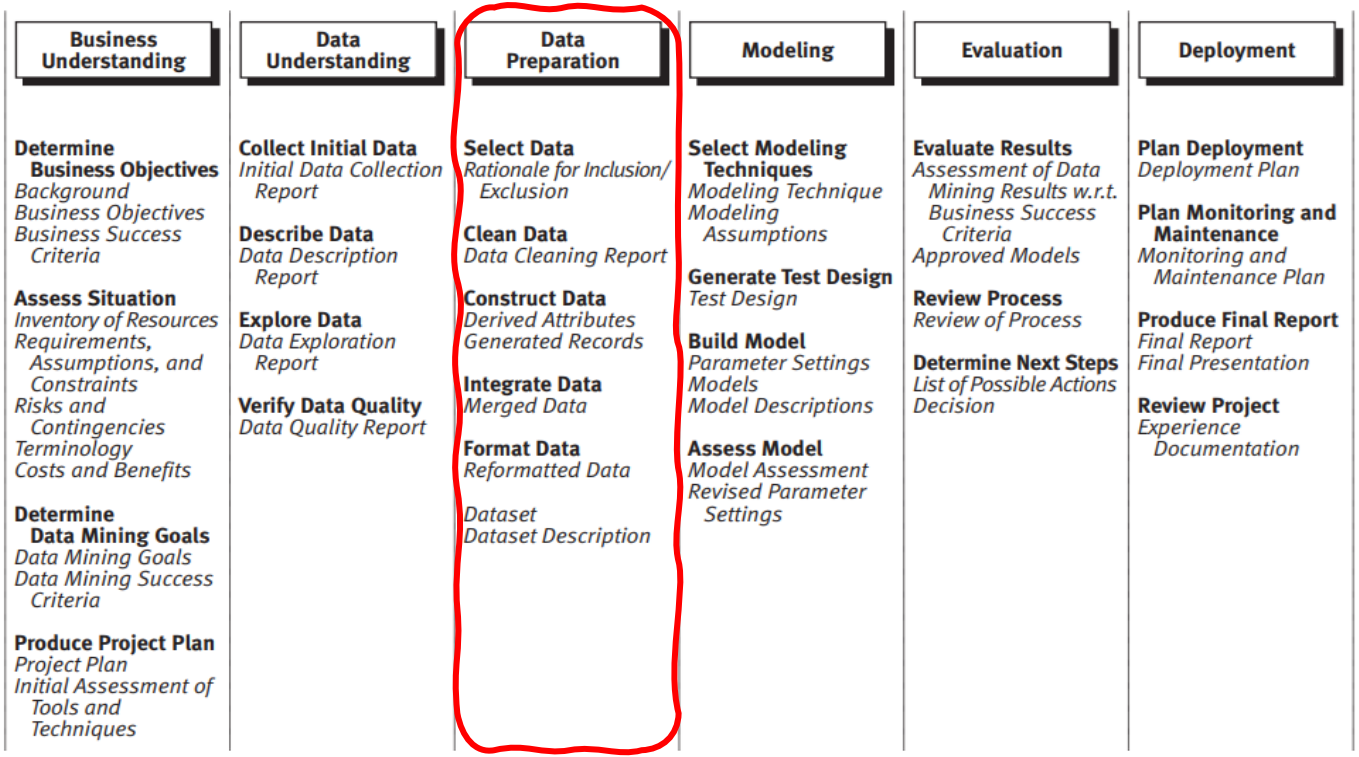


Figure 3: Generic tasks (bold) and outputs (italic) of the CRISP-DM reference model

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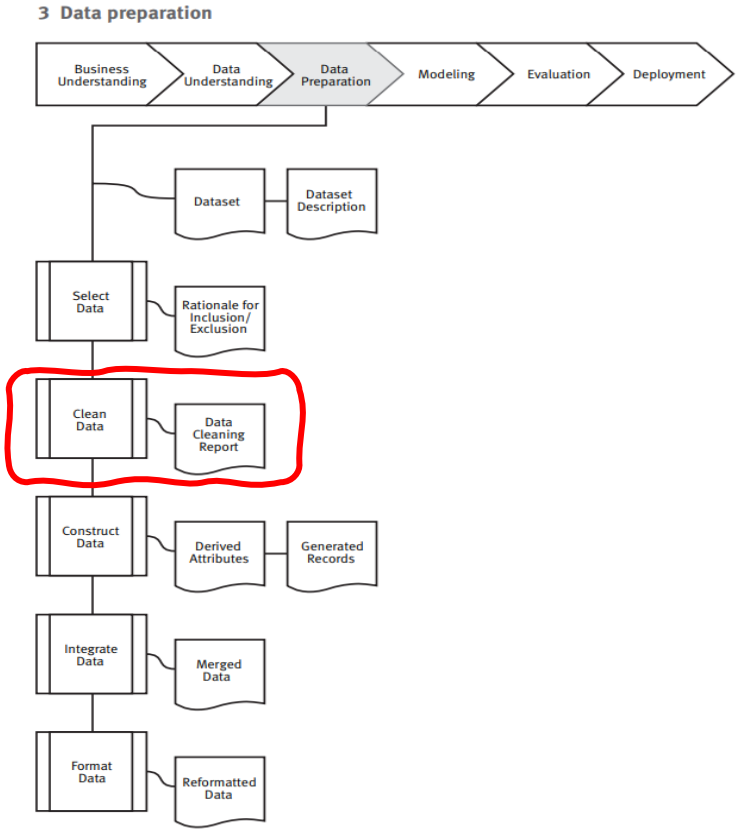
# Data Preparation

- Selecting
- Cleaning
- Constructing
- Integrating
- Formatting

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# Data Preparation

| A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LoanRange | BusinessName | Address | City | State | Zip | NAICSCode | BusinessType | RaceEthnicity | Gender | Veteran | NonProf | JobsRetained |
| a $5-10 million | A G EQUIPMENT COMPANY | 3401 W ALBANY ST | BROKEN ARROV | OK | 74012 | 333132 | Corporation | Unanswered | Unanswered | Unanswered | | 470 |
| a $5-10 million | ADVANTAGE ENERGY SERVICES LLC | 1010 N MAIN ST | MCALESTER | OK | 74501 | 211120 | Limited Liability | Unanswered | Unanswered | Unanswered | | 115 |
| a $5-10 million | AMERICAN PIPING INSPECTION, IN | 17110 E Pine | TULSA | OK | 74037 | 238210 | Corporation | White | Male Owned | Non-Veteran | | 344 |
| a $5-10 million | AXH HOLDINGS | 2230 E 49TH ST | TULSA | OK | 74105 | 332410 | Limited Liability | Unanswered | Unanswered | Unanswered | | 409 |
| a $5-10 million | B & H CONSTRUCTION, LLC | 301 James Dean Dr | NORMAN | OK | 73072 | 237110 | Limited Liability | Unanswered | Unanswered | Unanswered | | 250 |
| a $5-10 million | BECCO CONTRACTORS INC | 13737 E 46TH ST N | TULSA | OK | 74116 | 237310 | Corporation | Unanswered | Unanswered | Unanswered | | 0 |
| a $5-10 million | BENNETT CONSTRUCTION, INC. | 525 CENTRAL PARK DR | OKLAHOMA CIT | OK | 73105 | 236117 | Corporation | White | Male Owned | Non-Veteran | | 429 |
| a $5-10 million | BERENDSEN FLUID POWER, INC. | 401 S Boston Ave, Ste | TULSA | OK | 74103 | 423830 | Corporation | Unanswered | Unanswered | Unanswered | | 280 |
| a $5-10 million | BOFS MANAGEMENT LLC | 210 Park Ave | OKLAHOMA CIT | OK | 73102 | 213112 | Limited Liability | Unanswered | Unanswered | Unanswered | | 494 |
| a $5-10 million | CHC HOLDINGS | 3105 S MERIDIAN AVE | OKLAHOMA CIT | OK | 73119 | 621610 | Limited Liability | Unanswered | Unanswered | Unanswered | | 386 |
| a $5-10 million | COLLISION WORKS OF OKLAHOMA, LLC | 3224 SE 29TH ST | OKLAHOMA CIT | OK | 73115 | 811121 | Limited Liability | Unanswered | Unanswered | Unanswered | | 449 |
| a $5-10 million | COMPSOURCE MUTUAL INSURANCE COM | 1901 N Walnut | OKLAHOMA CIT | OK | 73105 | 524210 | Corporation | Unanswered | Unanswered | Unanswered | | 289 |
| a $5-10 million | COVERCRAFT INDUSTRIES, LLC | 100 Enterprise B;vd | PAULS VALLEY | OK | 73075 | 314999 | Limited Liability | Unanswered | Female Owne | Unanswered | | 475 |
| a $5-10 million | D & M CARRIERS LLC | 8125 SW 15TH ST | OKLAHOMA CIT | OK | 73128 | 484110 | Limited Liability | Unanswered | Unanswered | Unanswered | | 495 |
| a $5-10 million | DELAWARE RESOURCE GROUP OF OKLAH | 3220 Quail Springs Par | OKLAHOMA CIT | OK | 73134 | 336413 | Corporation | American Indi | Male Owned | Unanswered | | 500 |
| a $5-10 million | FUSION INDUSTRIES, LLC | 700 NE 63RD ST | OKLAHOMA CIT | OK | 73105 | 237130 | Limited Liability | White | Male Owned | Non-Veteran | | 217 |
| a $5-10 million | GDH CONSULTING INC | 6100 S YALE AVE | TULSA | OK | 74136 | 561320 | Corporation | Unanswered | Unanswered | Unanswered | | 500 |
| a $5-10 million | GRIFFIN COMMUNICATIONS, LLC | 7401 N Kelley Ave | OKLAHOMA CIT | OK | 73111 | 515210 | Limited Liability | Unanswered | Unanswered | Unanswered | | 434 |
| a $5-10 million | HAC, INC | 390 NW 36TH ST | OKLAHOMA CIT | OK | 73105 | 445110 | Subchapter S Co | Unanswered | Unanswered | Unanswered | | 500 |
| a $5-10 million | IMAGENET CONSULTING LLC | 913 N. Broadway Ave. | OKLAHOMA CIT | OK | 73102 | 423430 | Limited Liability | Unanswered | Unanswered | Unanswered | | 388 |
| a $5-10 million | INCEED LLC | 907 S DETROIT AVE | TULSA | OK | 74120 | 561311 | Limited Liability | White | Male Owned | Non-Veteran | | 478 |
| a $5-10 million | INDUSTRIAL PIPING SPECIALISTS INC. | 606 N. 145th East Ave | TULSA | OK | 74116 | 237120 | Subchapter S Co | White | Male Owned | Non-Veteran | | 421 |
| a $5-10 million | LATSHAW DRILLING COMPANY, LLC | 4500 S. 129th E Ave, S | TULSA | OK | 74134 | 211120 | Limited Liability | Unanswered | Unanswered | Unanswered | | |
| a $5-10 million | LEGEND ENERGY SERVICES, LLC | 5801 N BROADWAY EX | OKLAHOMA CIT | OK | 73118 | 213112 | Limited Liability | Unanswered | Unanswered | Unanswered | | 229 |
| a $5-10 million | LIFE. CHURCH OPERATIONS, LLC | 4600 E. 2nd Street | EDMOND | OK | 73034 | 813110 | Non-Profit Orgar | Unanswered | Unanswered | Unanswered | Y | 451 |

# Select data

## Task

### Select data

Decide on the data to be used for analysis. Criteria include relevance to the data mining goals, quality, and technical constraints such as limits on data volume or data types. Note that data selection covers selection of attributes (columns) as well as selection of records (rows) in a table.

### Output

Rationale for inclusion/exclusion List the data to be included/excluded and the reasons for these decisions.

# Clean data

**Task**

## Clean data

Raise the data quality to the level required by the selected analysis techniques. This may involve selection of clean subsets of the data, the insertion of suitable defaults, or more ambitious techniques such as the estimation of missing data by modelling.

## Data cleaning report

Describe what decisions and actions were taken to address the data quality problems reported during the Verify Data Quality task of the Data Understanding phase. Transformations of the data for cleaning purposes and the possible impact on the analysis results should be considered.

# Construct, Integrate, Format data

Deriving attributes:

e.g. A new column combining data from two other columns

Merging data:

e.g. joining together other datasets or tables, aggregating data

Format data:

e.g. Sorting, re-shaping, removing punctuation from headers etc.

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# Clean data

| ID | Cust-Name | DOB | Home_ town | Postcode | Gender | Product Rating | Feedback |
|---|---|---|---|---|---|---|---|
| C1001 | J.Smith | 10/02/1981 | London | LD1 2AB | M | 5 | excelent |
| C1002 | Mary Williams | 2.02/1981 | Exeter | EX1 2AB | | 4 | good |
| C1003 | Emily | 3/02/1980 | Plymouth | PL1 2AB | | 5 | excellent |
| C1004 | Sara Roberts | 1981-02-5 | York | | F | 3 | fair |
| C1005 | Dave | 15/02/1981 | | | M | | |
| C1006 | June Ford | 21/04/1981 | Glasgow | GA1 2AB | F | | good |
| C1007 | Winter Phillips | 11/12/1981 | York | Y01 2AB | F | 3 | goOd |
| C1008 | Julie | 19/08/1981 | | PL2 2AB | F | 2 | Acceptab;le |
| C1009 | Andi Smith | 1 May 1980 | Oxford | OX1 2AB | | 1 | poor |
| C1010 | Paula Penn | 10/11/1981 | Stafford | ST1 2AB | F | 10 | brilliant |

## Data Cleaning

- ID
- Variable type
- Extreme values
- Missing values
- Missing data
- Duplicate values
- Text processing – stop word removal, case conversion, special character removal

## Data Preparation

- Derived attributes
- Merge with other datasets for extra insight
- Reformat

# Re-shaping data

| Chipset | Site A | Site B | Site C | Site D |
|---|---|---|---|---|
| Hello | 15 | 8 | 30 | 27 |
| Snapdragon | 29 | 17 | 14 | 42 |
| Dimensity | 10 | 19 | 25 | 23 |

Wide

| Chipset | Site | DBH (mill) |
|---|---|---|
| Hello | A | 15 |
| Hello | B | 8 |
| Hello | C | 30 |
| Hello | D | 27 |
| Snapdragon | A | 29 |
| Snapdragon | B | 17 |
| Snapdragon | C | 14 |
| Snapdragon | D | 42 |
| Dimensity | A | 10 |
| Dimensity | B | 19 |
| Dimensity | C | 25 |
| Dimensity | D | 23 |

Long

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## Basic data types in R:

- `numeric` - (10.5, 55, 787)
- `integer` - (1L, 55L, 100L, where the letter "L" declares this as an integer)
- `character` (e.g postcodes, IDs, names)
- `factor` ('female', 'male')('excellent', 'okay', 'poor')
- `logical` (a.k.a. boolean) - (TRUE or FALSE)

We can use the `class()` function to check the data type of a variable

Or glimpse() to see the class of each column in a dataset

is.na() to find missing values

## Useful commands for inspecting data in R

**head:** this by default prints the first 6 rows of the dataframe

**tail:** this by default prints the last 6 rows to the console

**str:** this prints the structure of your dataframe

**dim:** this by default prints the dimensions, that is, the number of rows and columns of your dataframe

**colnames:** this prints the names of the columns of your dataframe

**summary:** this function provides summary statistics on the columns of the data frame

[How to merge in R (youtube.com)]

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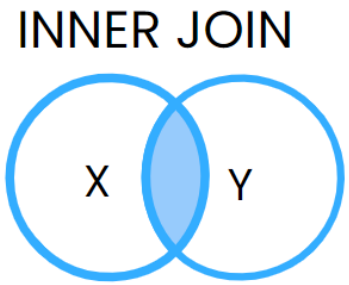
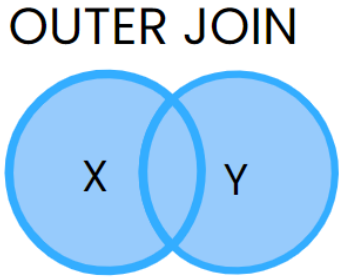
# Merging / joining

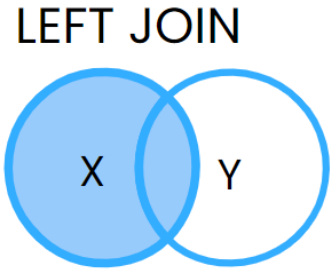
Inner join consists of merging two dataframes in one that contains the common elements of both, as described in the following illustration:



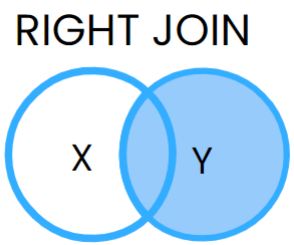

Full (outer) join merges all the columns of both data sets into one for all elements:




Left (outer) join consists of matching all the rows in the first data frame with the corresponding values on the second.




The right join in R is the opposite of the left outer join. In this case, the merge consists of joining all the rows in the second data frame with the corresponding on the first.




[How to merge data in R using R merge, dplyr, or data.table | InfoWorld]

# Tasks for next week: Data visualisation

Read: Storytelling with Data (pdf on ELE)

Watch: Turning bad charts into compelling stories Dominic Bohan | TEDxYouth@Singapore - YouTube

Listen: Data Is Personal with Evan Peck – Data Stories

Do the Rstudio primer/visualisation Posit Cloud

Download from ELE and save files for Week 3 workshop

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Any questions?

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