Data Science Upskilling Workshop

Session 3: Data Model, Data Wrangling, and Visualization

Oren Livne and Jiangang Hao
Educational Testing Service

NCME 2023 Training Workshop – 4/12/2023

This session featuring…

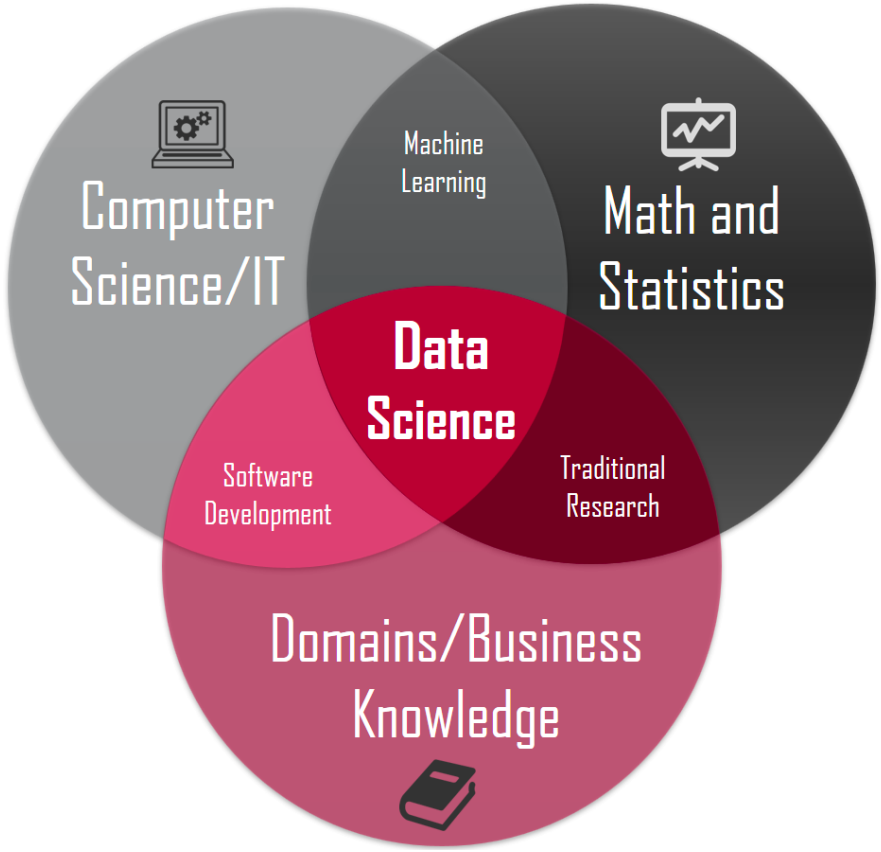
- Data science basics
  - Data science overview
  - Data storage – data lake, warehouse, mart
  - Data model – document, relational, graphic
  - Data processing
- Data wrangling
  - Parsing **XML and JSON structured formats**
  - Parsing **unstructured** files
- Interactive visualization
- Dashboard

What is Data Science

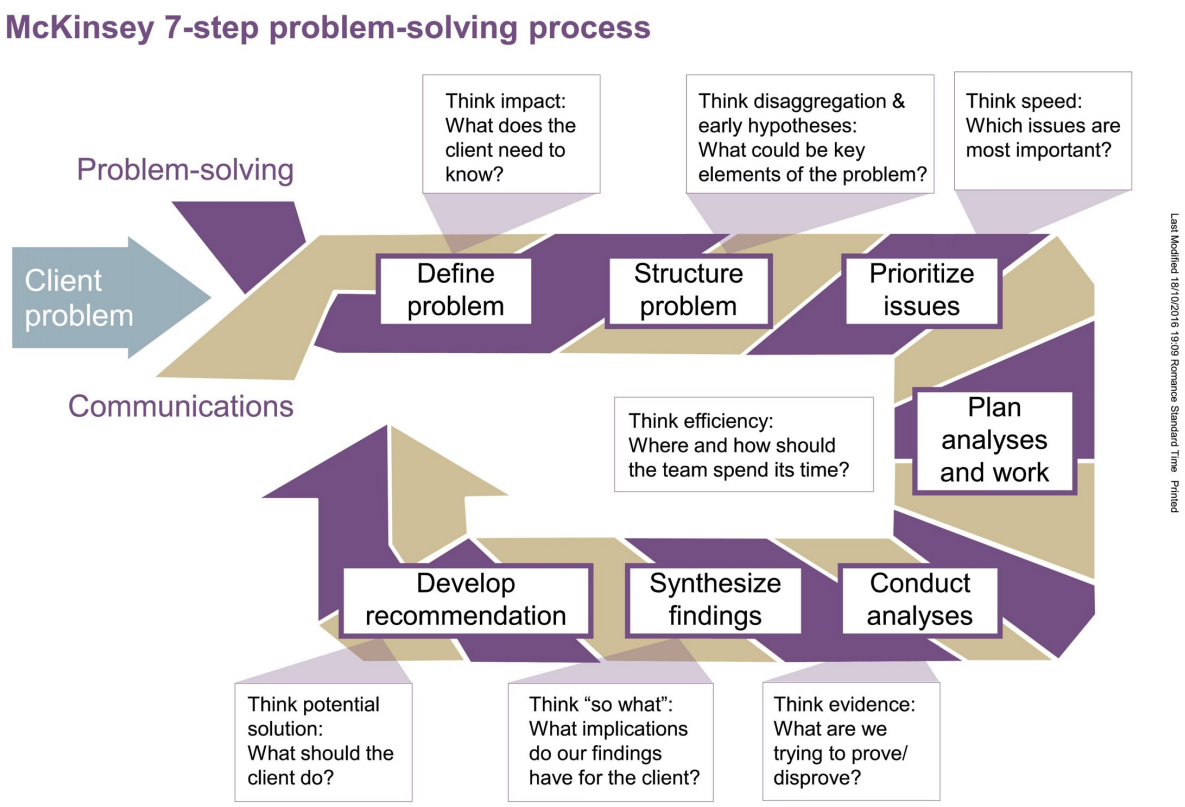
What is Data Science

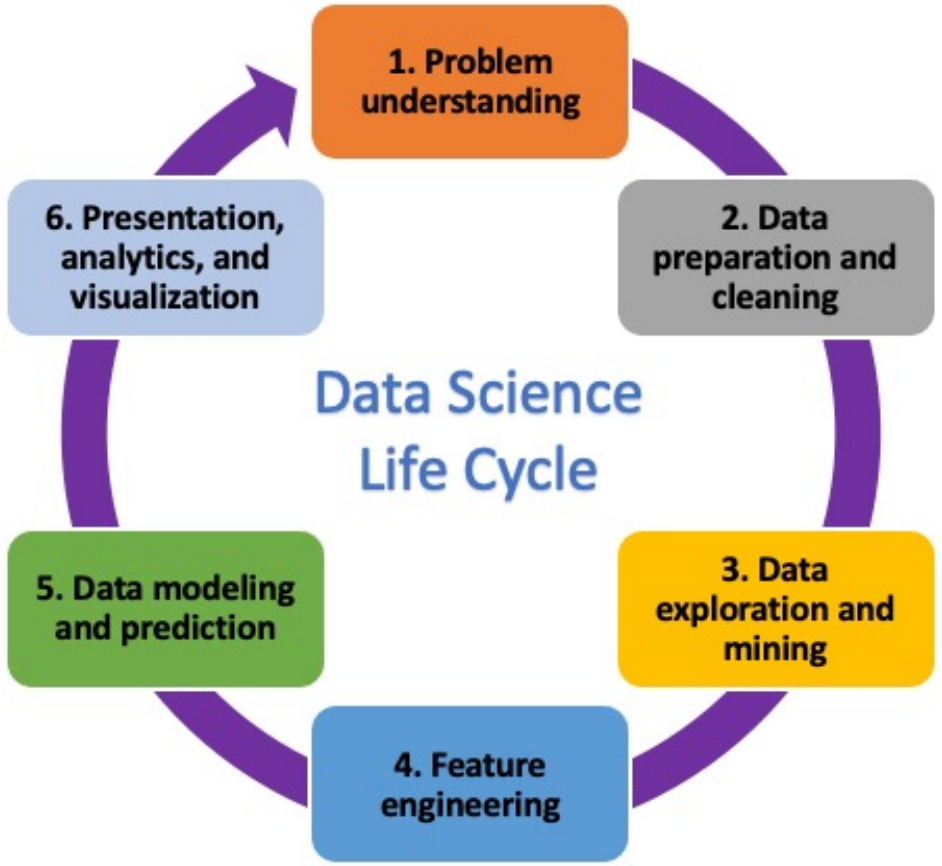
Data science is an inter-disciplinary field that uses scientific methods, processes, algorithms and systems to extract knowledge and insights from many structural and unstructured data

- Wikipedia

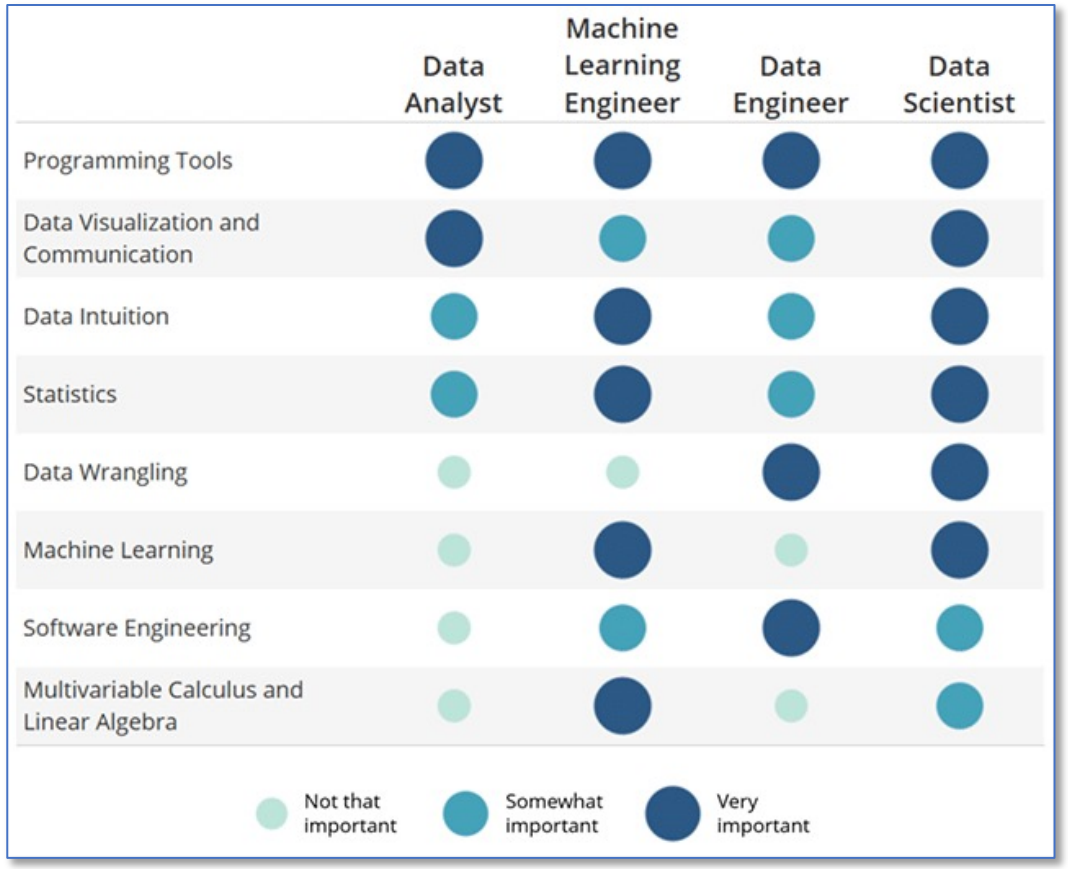


Life Cycle of Data Science Projects





Skills Needed



https://www.udacity.com/blog/2014/11/data-science-job-skills.html

To be a good scientist, one also needs

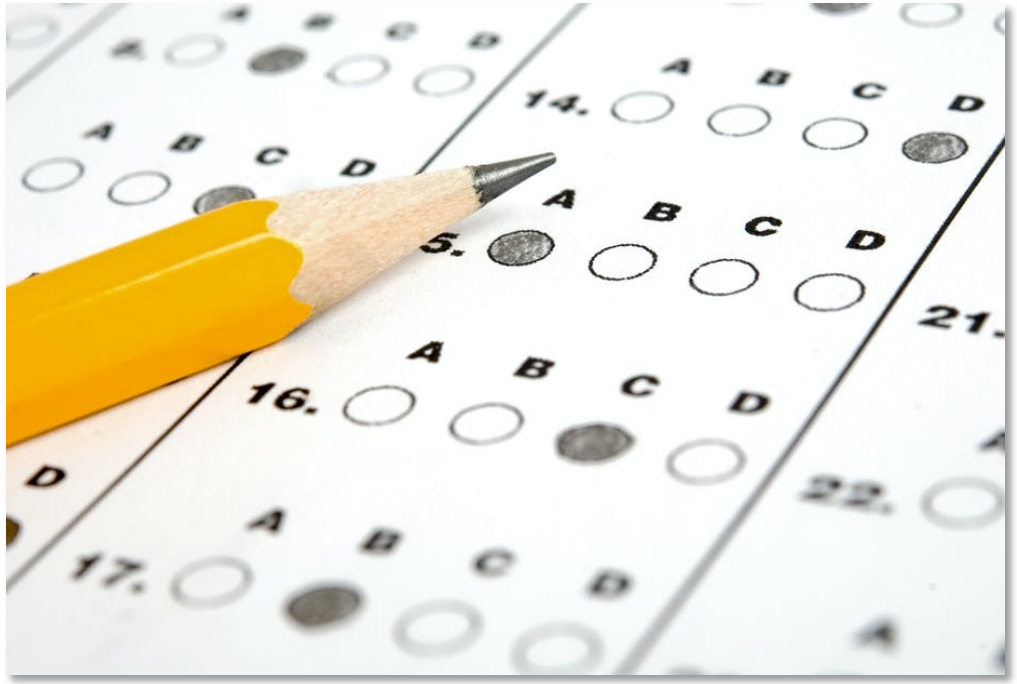
- Curious & creative
- Patient, detail-oriented, & persistent
- Open-minded & courageous
- Computational thinking
- Critical thinking
- Problem solving
- Hands-on and doing
- Collaborative and communicative

https://www.canr.msu.edu/news/what_makes_a_good_scientist

Why it matters in assessments?

Changing

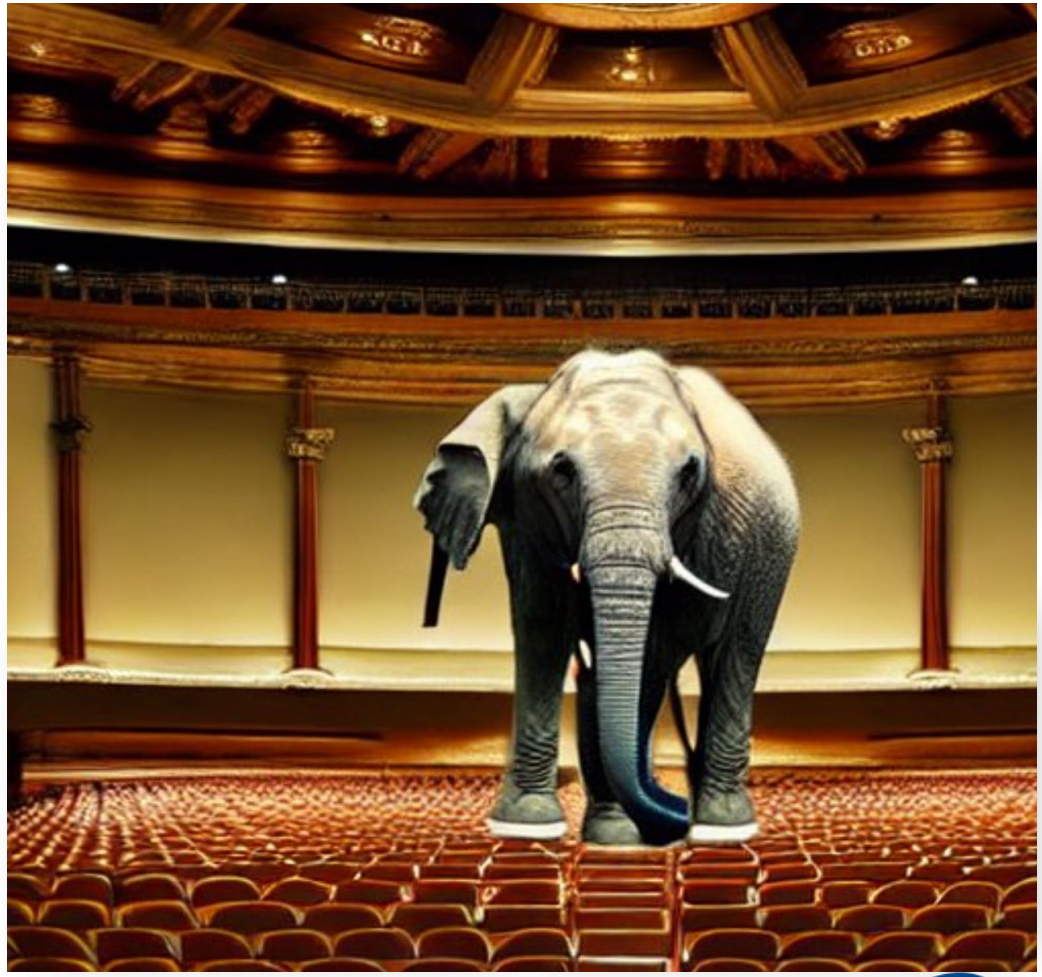
Assessments do not have to be always in this way



Digital technology affords much more

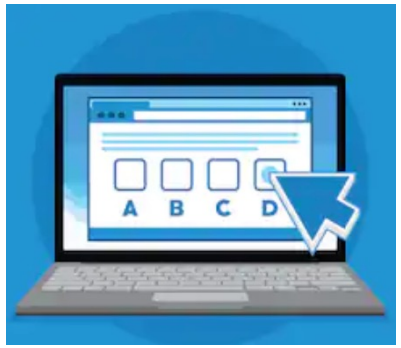
Impact of Digital Technology

- Digital technology completely changed the way of learning and assessment
  - Games, simulations, virtual reality, AI, online interaction, etc.
  - Performance/competency-based assessments for new skills become feasible
- Data are the key to materialize the promises of digital technology
  - Variety of new types of data from more authentic settings
  - Don’t just focus on exhausting ways to handle the 0/1 responses and miss the elephant in the room



Process Data in Assessments

Tasks



Interaction data

Learners

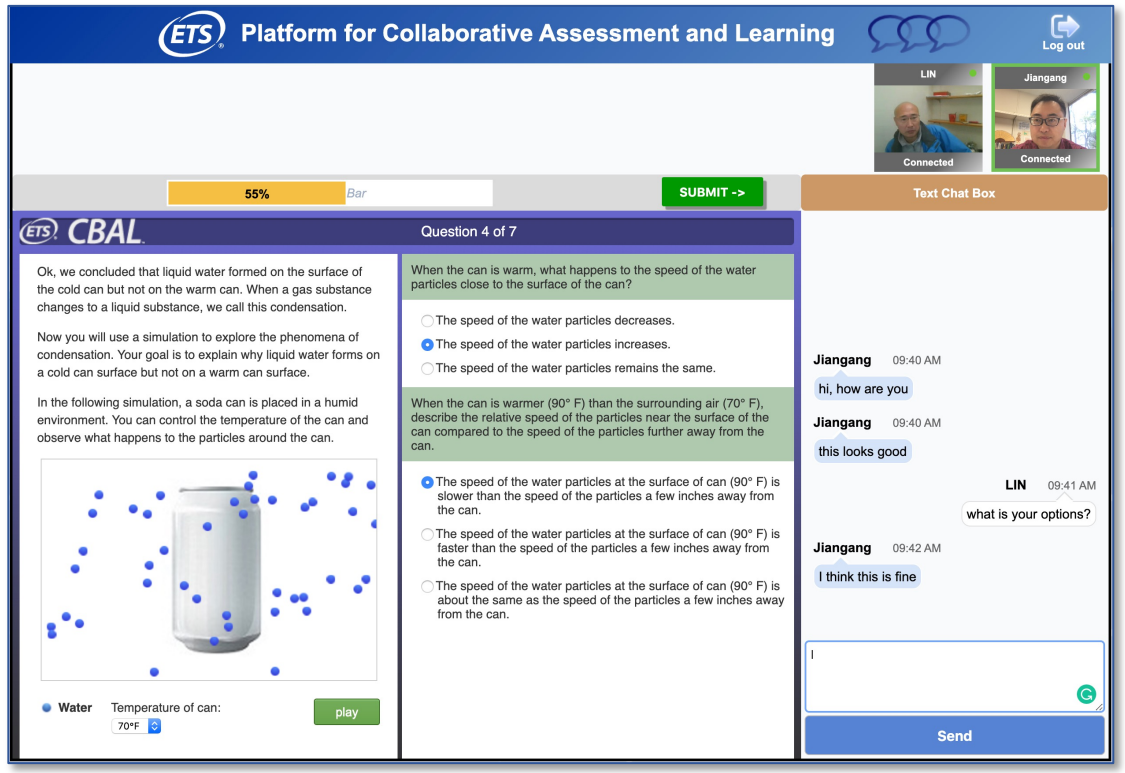
interaction information between learners and learning/assessment tasks, allowing better understanding of the learners and the tasks

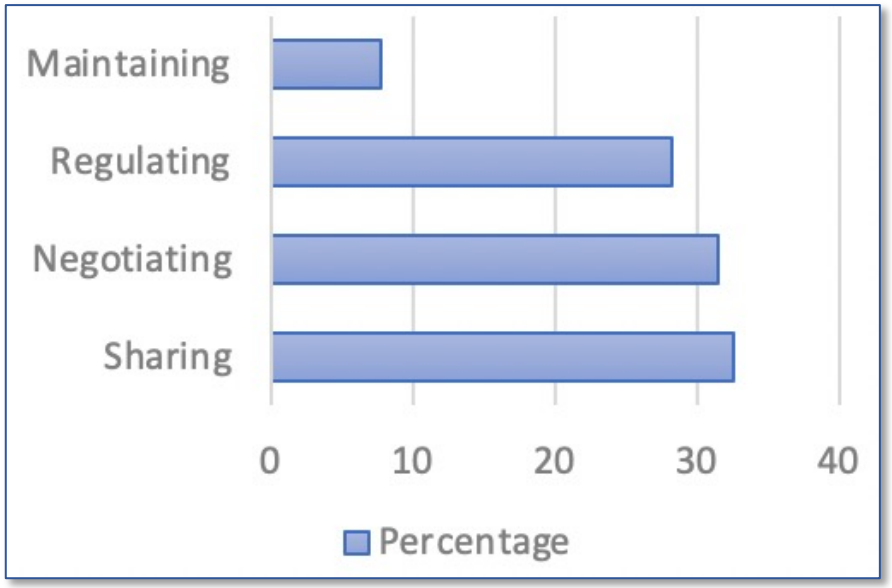
Main uses:

1. Providing evidence for new constructs
2. Providing direct support to the psychometric operations
3. Informing designs of items and delivery platforms
4. Pushing the development of new psychometric and statistical models
5. Uncover new psychology and cognitive behaviors
6. Providing information to support test security and remote testing
7. Creating more informative reporting to feedback various stakeholders.
8. Providing information on group difference and shedding new light on fairness

Hao, NCME 2021

Use Case 1 Example: Providing Evidence for New Constructs





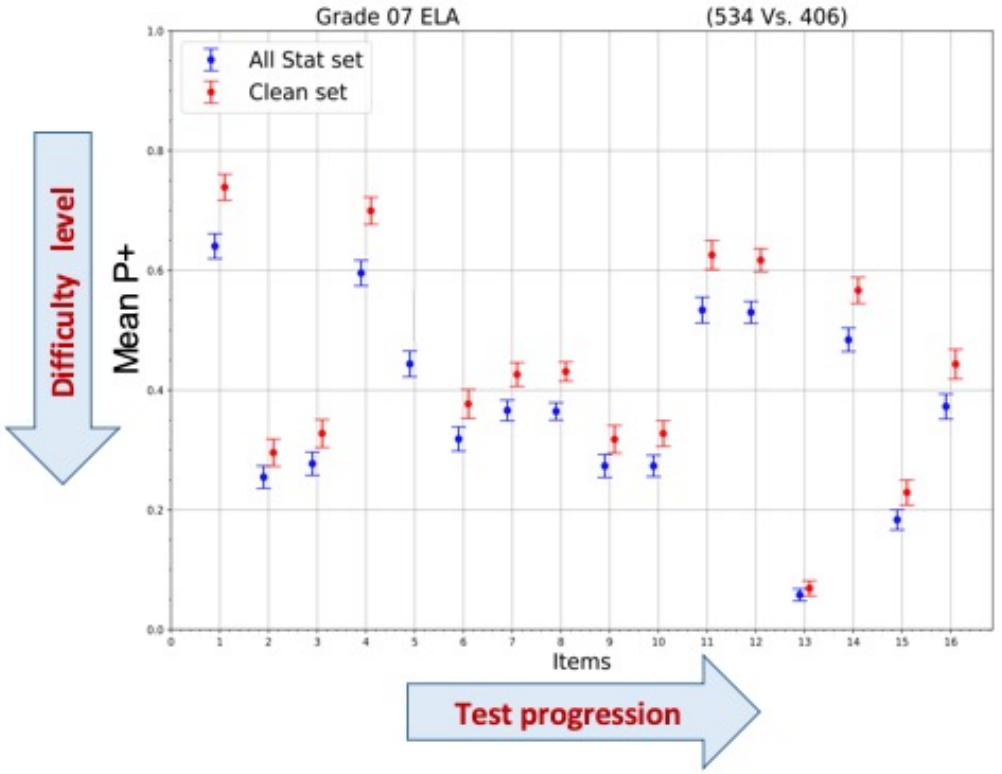
Hao, Liu, von Davier, Lederer, et al., 2017

Measuring collaborative problem solving based on the collaboration process data

Hao, NCME 2020

Use Case 2 Example: Support Psychometric Operations

Better item calibration



Definitions:

- Clean set: students who complete the assessment in a single session
- All Stat set: students who complete the assessment in a single session and in multiple sessions

Findings

- Different samples lead to different item parameter estimates
- The difference of item mean P+ is not affected much by the item location in the test
- Easier items are more affected

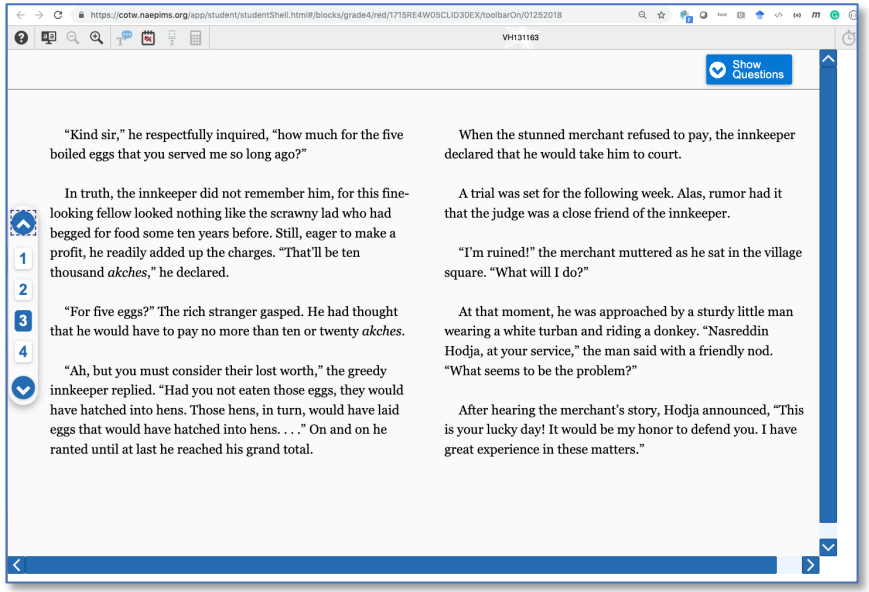
Based on data from ETS Winsight assessment

Hao, NCME 2019

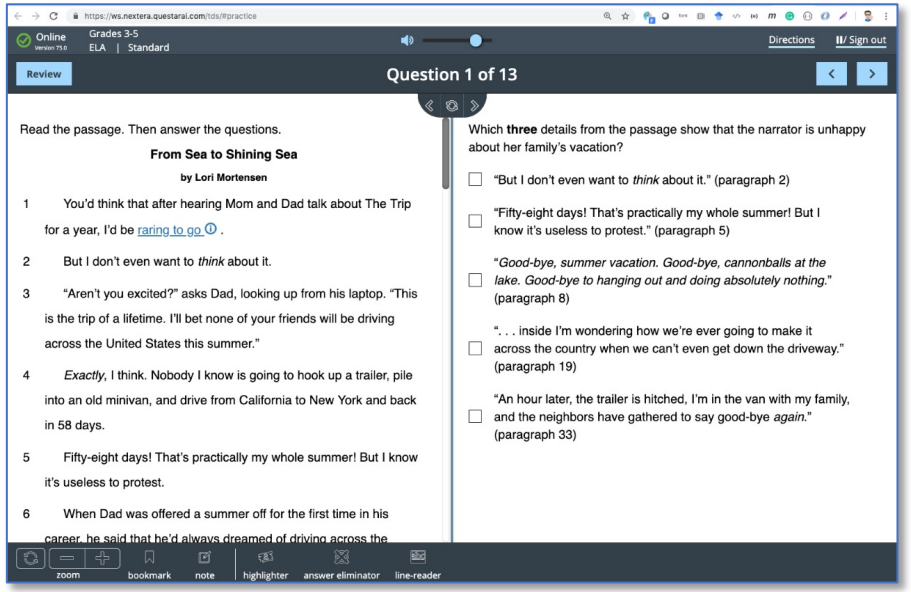
Use Case 3 Example: Informing Design

- For each item type, there should be an optimal design that allows us to get more information than others.
- Considering the reading item, the design on the left allows us to know the time student spend on reading passage and responding question

NAEP



Winsight

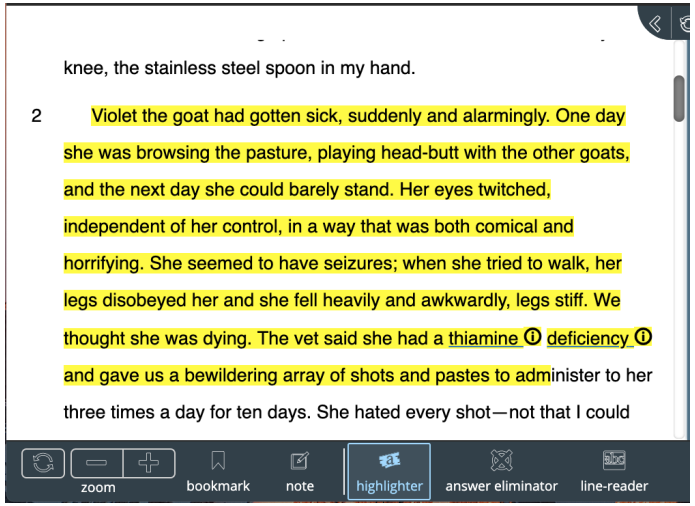


Process data provide an opportunity for us to summarize the optimal design for different item types to get the most information.

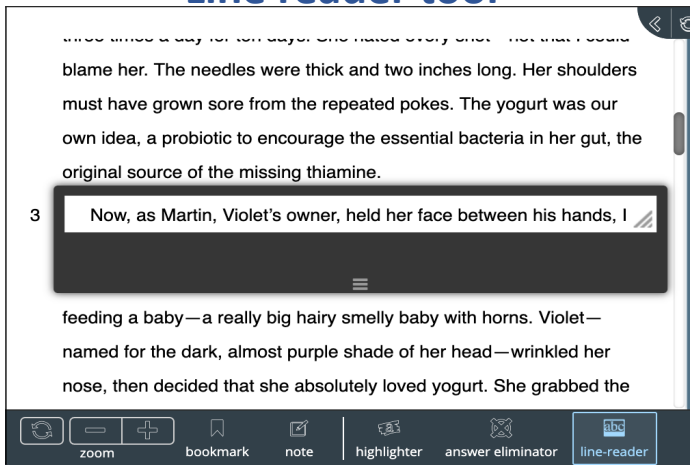
Hao, NCME 2019

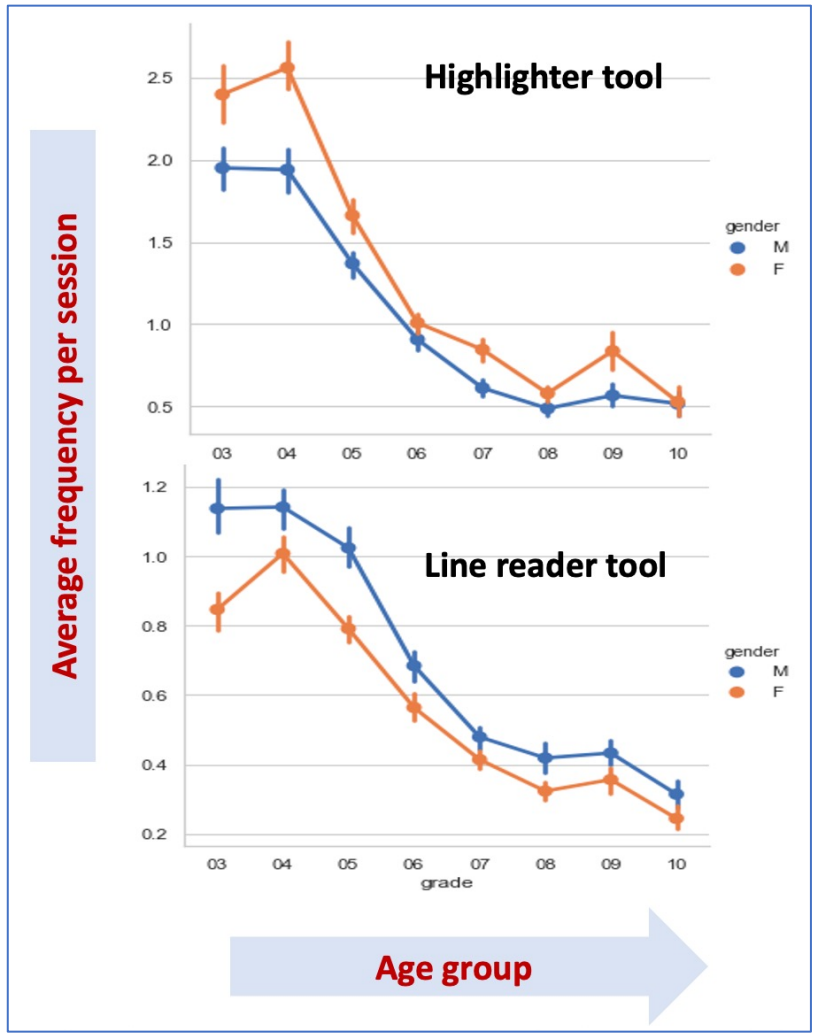
Use Case 5 Example: Uncover new psychological and cognitive behaviors

Highlighter tool



Line reader tool





Observations:

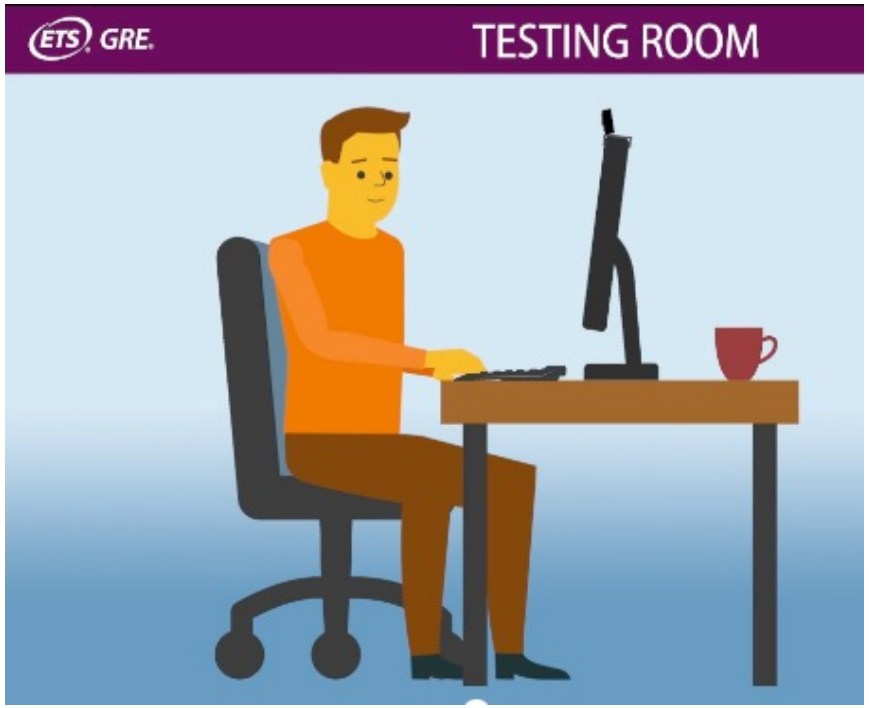
- Girls tend to use more highlighter tool
- Boys tend to use more line reader tool
- Decreasing trend of tool usage

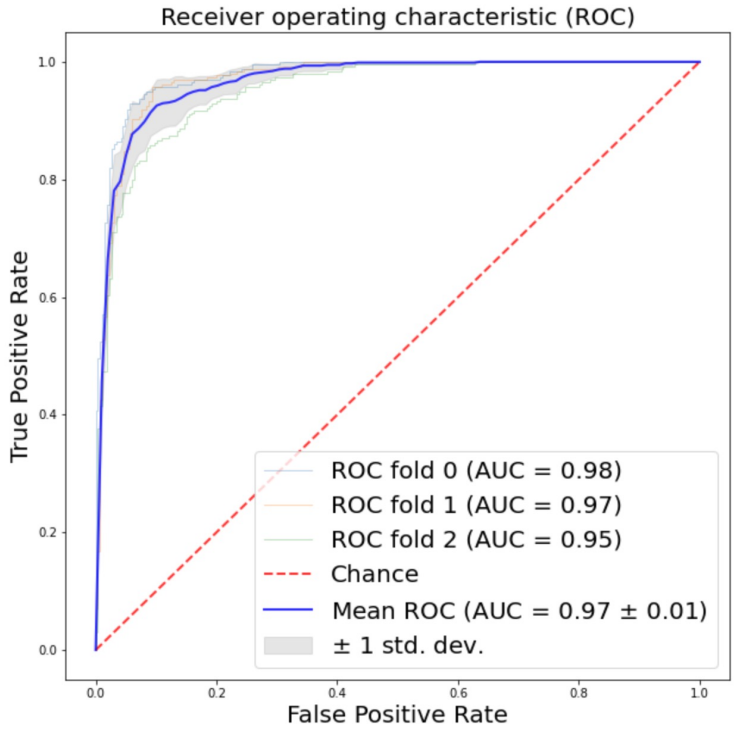
Key message:

- Analytics helps to identify subgroup difference to allow tailored strategy
- In business settings, marketing and sales strategy

Use Case 6 Example: Providing Information to Support Test Security

Detecting remote desktop access in remote testing based on clickstream data





Hao & Li, 2021

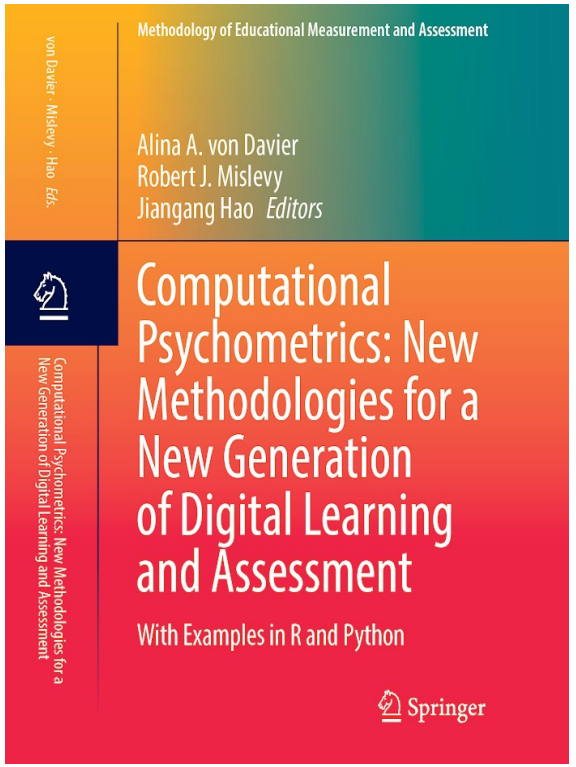
Hao, NCME 2022

Practical Challenges

- Who is going to do the work and where are we going to find them?
- New skills are needed
  - Design systems by leveraging the new digital affordances
  - Data science
  - Machine learning
  - Natural language processing
- How much should a psychometric researcher learn?
- Where to learn these skills?

A New Book

Computational Psychometrics is a term introduced by Alina von Davier in 2015 to describe an interdisciplinary field that fuses theory-based psychometric principles and data-driven computational methods from data science, machine learning, natural language processing, and other quantitative disciplines to handle the large-scale and high-dimensional data from digital learning and assessment.



https://bookauthority.org/books/new-educational-assessment-books?t=14nb4c&s=award&book=3030743934

Coverage

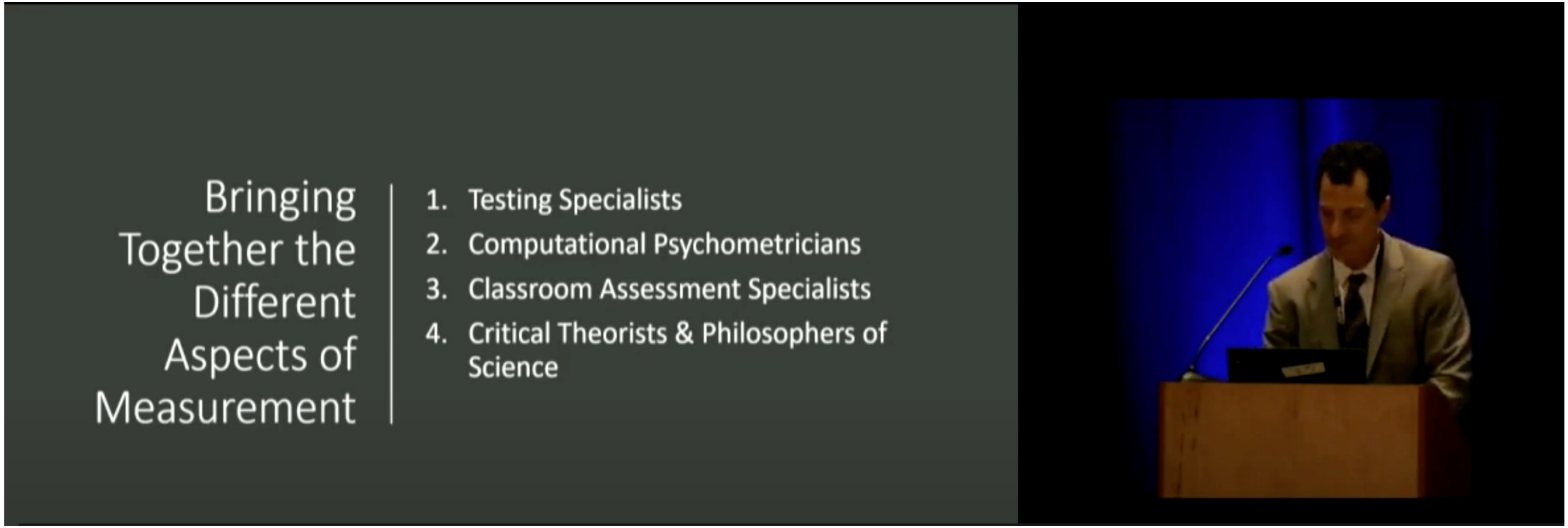
- Conceptualization
  - Next generation learning and assessment
  - Computational psychometrics
  - Virtual performance-based assessment
  - Adaptive learning
- Methodology
  - Concepts and models from psychometrics
  - Bayesian inference
  - Data science
  - Machine learning
  - Time series and stochastic process
  - Social network analysis
  - NLP - text mining and automated scoring
- Code examples

  https://github.com/jgbrainstorm/computational_psychometrics

Why We Need It?

- Intrinsic need to expand the existing psychometric methodologies to include new methods from, e.g., data science, machine learning, natural language processing and other quantitative disciplines, to address the new challenges of learning and assessment in the digital age. When many new methods are included, introducing a new term to encompass these new features will be more convenient and effective for communication.
- Practical challenges of preparing the workforce.
  - Applicants from psychometrics programs do not have the needed data science/machine learning skills (and mindsets) to process and model complex data from digital tasks
  - Applicants with data science/machine learning skills from other disciplines, such as computer science, generally know very little about the core values of psychometrics.
  - Hiring people who do not know the core values of the substantive area poses a big retention challenge for organizations, as they may quickly move on if they find they are not interested in the area at all after a few months.
  - It is imperative to prioritize a set of new methodologies and integrate them with the core values of psychometrics in a principled manner to help prepare a stable workforce for digital learning and assessment in the future.
- Bridge people from other quantitative disciplines (such as computer science, applied mathematics, physics, and others) to digital learning and assessment.
  - Providing a concise coverage of psychometrics' established values and methods could help them better understand how to apply their skills to join forces to promote learning and assessment in a digital age.

Computational Psychometrics in Measurement



Briggs, NCME Presidential Address, 2022

Prioritized Areas

- Data science
  - Data science basics
  - Data wrangling and processing
  - Visualization and dashboarding
- Machine learning/AI
  - Supervised and unsupervised learning
  - Some use cases
  - Software packages

Workshop

- Natural Language Processing
  - Language models
  - Text representation and mining
  - Automated scoring
  - Deep learning-based models

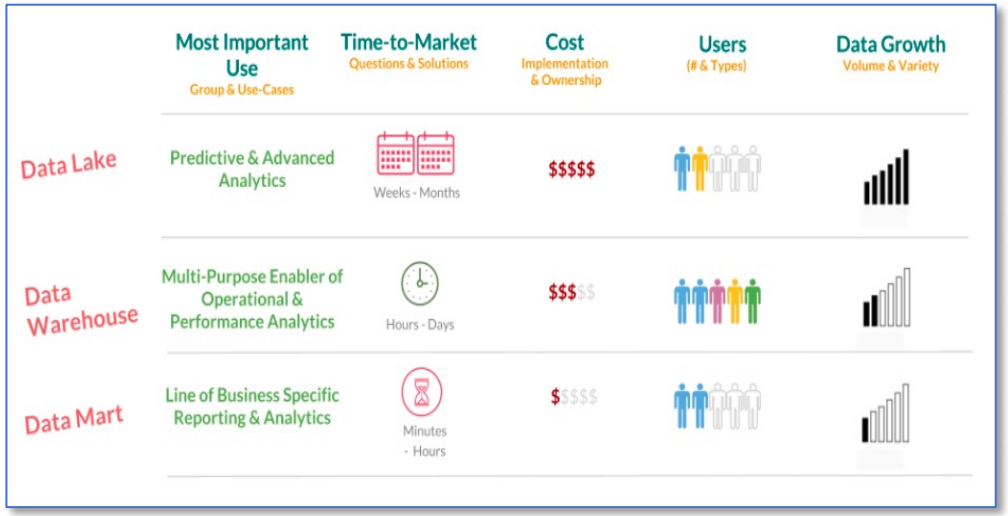
Data Type and Data Model

Types of Data

- ***Raw*** data (structured or non-structured)
  - Images, videos, audios
  - Documents
  - Records from a single testing sessions
  - …
- ***Processed/value-added*** data (mostly structured)
  - Features from raw data
  - Rational tables
  - Records of many students' test score
  - …

Data Storage

- **Data Lake**: a centralized repository that allows you to store all your structured and unstructured raw data at any scale
  - File folders
  - Cloud-based folder - AWS S3 bucket
- **Data Warehouse**: a central repository of processed data that can be used for multiple purpose
  - RDBMS: Relational Database Management System
  - MySQL, Oracle, PostgreSQL, etc.
- **Data Mart**: a subsection of the data-warehouse, designed and built specifically for a particular department/business function.



https://www.holistics.io/blog/data-lake-vs-data-warehouse-vs-data-mart/

Example

We need to standardize the data so that the process flows smoothly

How?

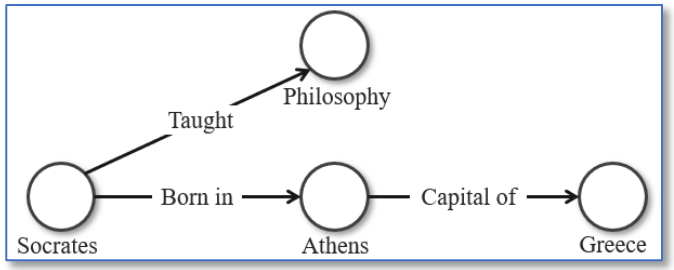
Data Model

A data model is an abstract model that organizes elements of data and standardizes how they relate to one another and to the properties of real-world entities. (Wikipedia)

- **Relational Model (SQL)**
  - Data is organized into relations (tables in SQL DB) where each relation is an unordered collection of tuples (rows in SQL) – Codd (1970)
  - Suited for data where there are many-to-many relations
  - SQL database: Oracle, PostgreSQL, MySQL, etc.
- **Document Model (NoSQL)**
  - Hierarchical/tree structure (JSON/XML)
  - Suited for data where mostly are one-to-many relations
  - NoSQL database: Mongodb, Redis, CouchDB, Hbase, etc.
- **Graph Model**
  - Vertices (nodes or entities) and edges (relationship or arcs)
  - Social graph: Vertices -> people, Edges -> which people know each other
  - Web graph: Vertices -> web pages, Edges -> html links
  - Suited for data where the many-to-many relationship is too complicated to be handled by the relational model
  - Neo4j, ArangoDB, etc.

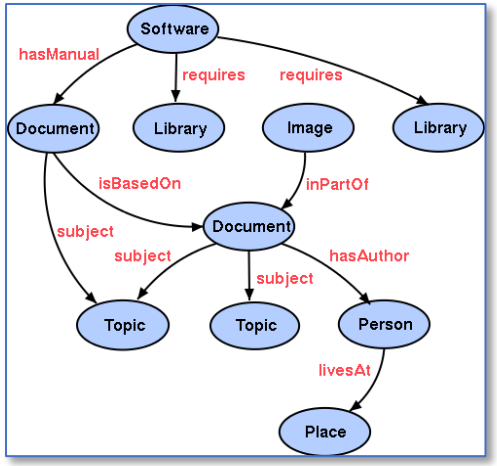
Triple Store and RDF

- **Triple Store Model**
  - (subject, predicate, object)
  - E.g. (Jiangang, like, apple), (Oren, like, orange)
  - Knowledge graph for search engine and AI applications



https://towardsdatascience.com/auto-generated-knowledge-graphs-92ca99a81121

- **Resource Description Framework (RDF)**
  - Semantic web (Berners-Lee, 2001)
  - Similar to the triple store model, but referring to webpages
  - Uniform Resource Identifier (URI)
    - URN: Uniform Resource Name
    - URL: Uniform Resource Locator
  - (URI_1, URI_2, URI_3)

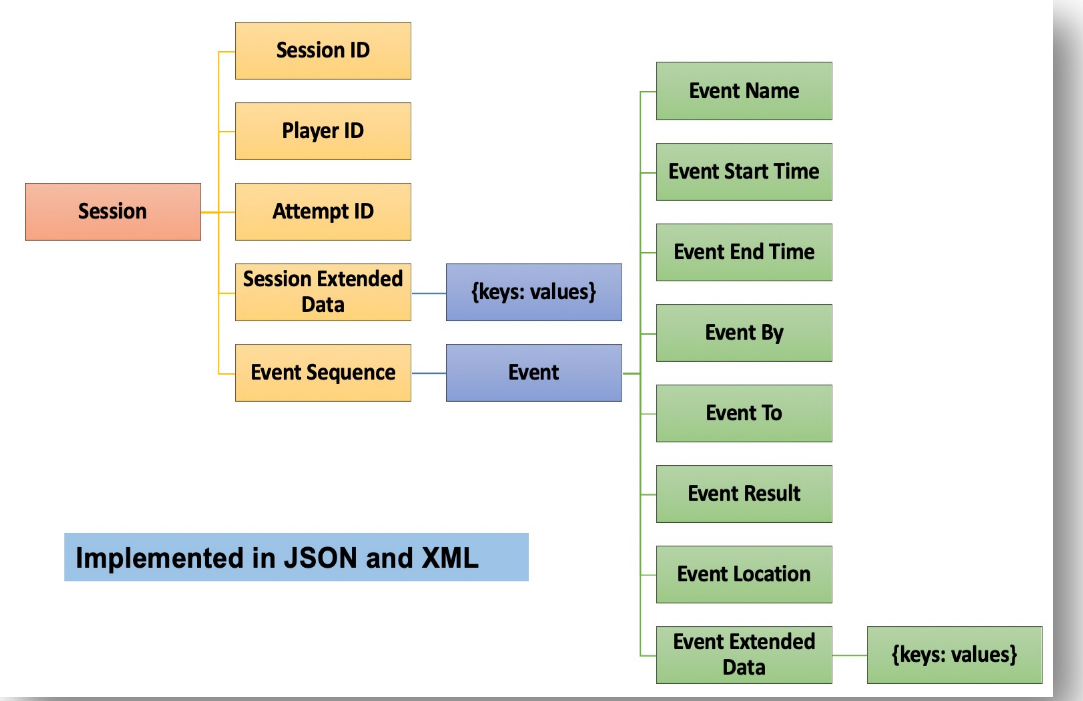


https://vodkhang.com/intelligent-system/semantic-technology-and-its-application

Data Models in Learning and Assessments

- **xAPI**: experience API (or Tin Can API) is an eLearning specification that makes it possible to collect data about the wide range of experiences a person has within online and offline training activities.
  - Evolved from SCORM (Shareable Content Object Reference Model, http://scorm.com)
  - For learning management system (LMS)
  - Triple store style data model: Actor > Verb > Object (Activity)
  - https://adlnet.gov/projects/xapi-architecture-overview/
- **IMS Global Learning Consortium' Caliper**: IMS enables a plug-and play-architecture and ecosystem that provides a foundation on which innovative products can be rapidly deployed and work together seamlessly.
  - For learning management system (LMS)
  - Triple store style data model: Actor > Verb > Object (Activity)
  - https://www.imsglobal.org/activity/caliper#caliperpublic
- **ETS Data Model for Virtual Performance Assessment**
  - Document data model for process data from virtual performance assessments (VPAs, such as game/simulation-based assessments)
  - https://onlinelibrary.wiley.com/doi/full/10.1002/ets2.12096

ETS Data Model for Virtual Performance Assessment



- An extra process in Evidence Centered Design
- Log file -> Evidence Trace File


```
gameLog: [
 - {
      sessionID: "7402",
    + playerID: [2],
    - sessionExtData: {
          n_player: 2,
          team_assembly_mode: "random",
          P1: "jiangang",
          P2: "hao",
      },
    - eventSequence: [
        - {
              eventName: "chat",
              eventStartTime: "2020-05-17T00:28:48Z",
              eventEndTime: "2020-05-17T00:28:48Z",
              eventBy: "jiangang",
              eventTo: "others",
              eventResult: "hi",
              eventLocation: "slide1-step0",
              eventExtData: { },
          },
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
        + {8},
      ],
      teamID: "hao_jiangang",
      attemptID: 25,
   }
]
```


JSON Implementation

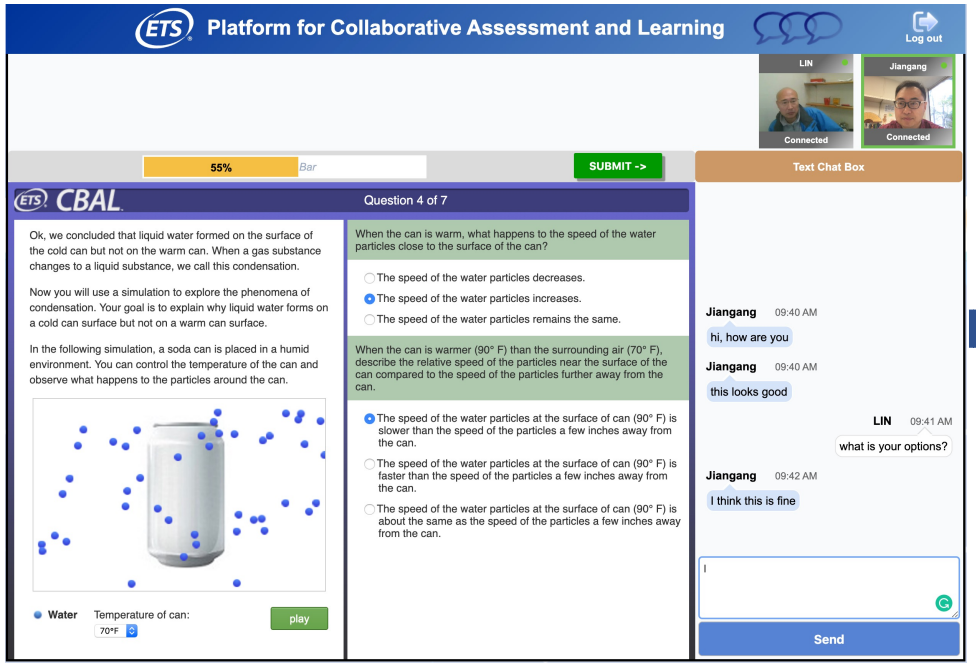

```
▼ <gameLog xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  ▼ <session>
      <sessionID> 7402 </sessionID>
      <teamID> hao_jiangang </teamID>
    ▶ <playerID>
      <attemptID> 25 </attemptID>
      <sessionExtData>
      ▶ <pair>
      ▶ <pair>
      ▶ <pair>
      ▶ <pair>
      ▶ <pair>
      </sessionExtData>
    ▼ <eventSequence>
        <event>
          <eventName> chat </eventName>
          <eventStartTime> 2020-05-17T00:28:48Z </eventStartTime>
          <eventEndTime> 2020-05-17T00:28:48Z </eventEndTime>
          <eventBy> jiangang </eventBy>
          <eventTo> others </eventTo>
          <eventResult> hi </eventResult>
          <eventLocation> slide1-step0 </eventLocation>
        </event>
      ▶ <event>
      ▶ <event>
      ▶ <event>
      ▶ <event>
      ▶ <event>
      ▶ <event>
      ▶ <event>
      ▶ <event>
      ▶ <event>
      ▶ <event>
      ▶ <event>
      ▶ <event>
      ▶ <event>
      ▶ <event>
      ▶ <event>
      ▶ <event>
      </eventSequence>
    </session>
  </gameLog>
```

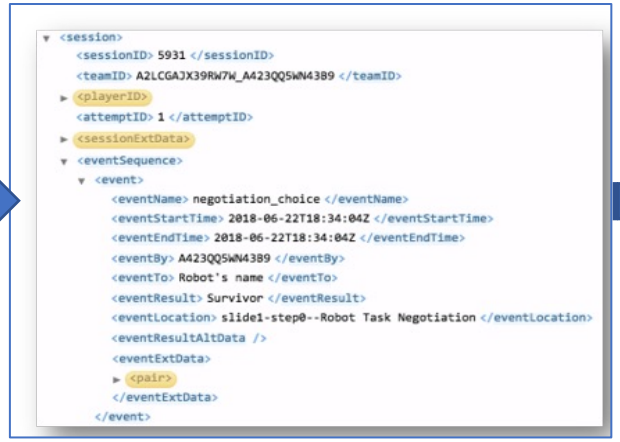

XML Implementation

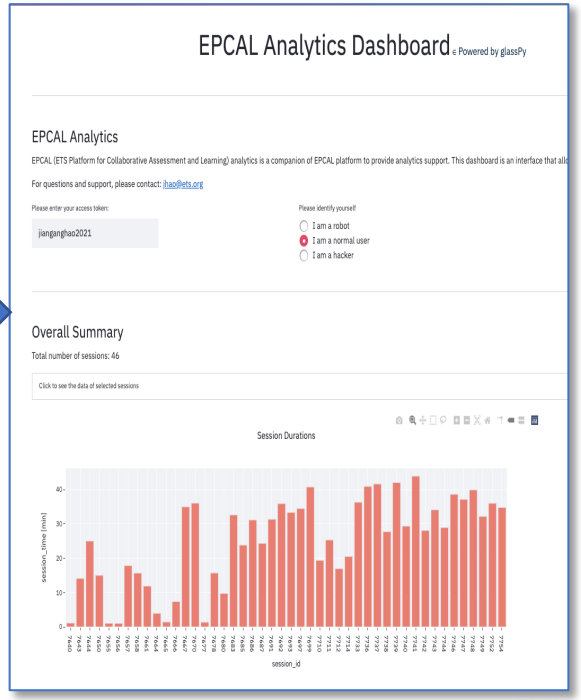
Hao et al., 2014; 2016; Hao & Mislevy, 2018

A Full Implementation in EPCAL

Full implemented in the ETS Platform for Collaborative Assessment and Learning







https://onlinelibrary.wiley.com/doi/full/10.1002/ets2.12181

Data Processing

General Steps

- Data integration through ETL
  - Extract data from different sources (e.g., data lakes)
  - Transform the data to improve quality and consistency
  - Load data into a target database
- Data mining and feature engineering
- Analytics, statistical modeling, machine learning

Analytics, Statistical Modeling, Machine Learning

- Analytics
  - Discovery, interpretation, and communication of meaningful patterns in data and apply these patterns towards effective decision making.
  - Suited for data from most digital learning and assessment tasks
- Modeling
  - The use of mathematical models and statistical assumptions to generate sample data and make predictions about the real world.
  - Psychometric/statistical modeling (e.g., Bayes net, IRTs, CDM, many others)
  - Cognitive modeling (e.g., ACT-R, SOAR, many others)
  - Better suited for data from carefully designed virtual performance tasks
- Machine learning
  - Methodologies that allow computers to “learn” the relationship among numerical representations of data without explicit instructions by human experts.
  - Supervised, unsupervised, semi-supervised, reinforcement

Hao & Mislevy, 2021

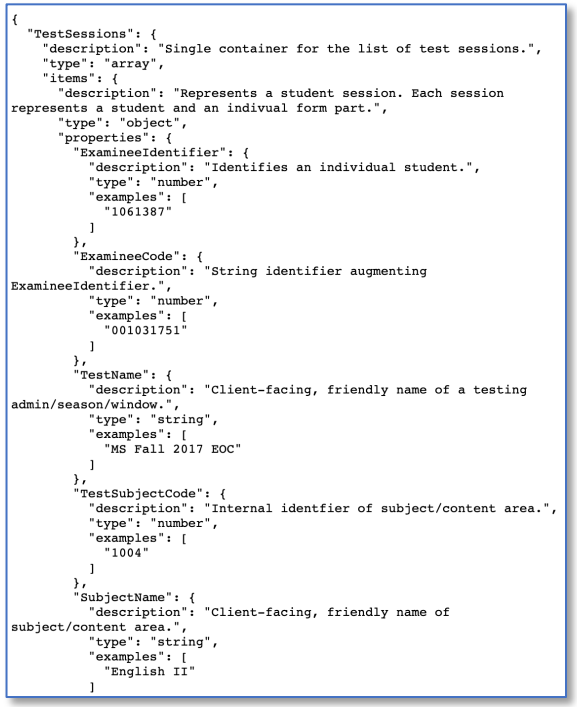
Types of Data Processing

- Batch processing
  - Process data after the data are collected
  - E.g., Apache Hadoop, …
- Stream processing
  - Process live data
  - E.g., Apache Kfaka, Storm, Streamz, …
- Micro-batch processing
  - Something in between the Batch and Stream processing
  - Apache Spark

The landscape of the software tools changes very fast and new tools emerge from time to time

Analytics Strategy for Response Process Data

- Directly parse the JSON/XML file to extract information
- Transform sequential data to tabular data to leverage the existing tools for handling tabular data (e.g., pandas)



```
{
  "TestSessions": {
    "description": "Single container for the list of test sessions.",
    "type": "array",
    "items": {
      "description": "Represents a student session. Each session
represents a student and an indivual form part.",
      "type": "object",
      "properties": {
        "ExamineeIdentifier": {
          "description": "Identifies an individual student.",
          "type": "number",
          "examples": [
            "1061387"
          ]
        },
        "ExamineeCode": {
          "description": "String identifier augmenting
ExamineeIdentifier.",
          "type": "number",
          "examples": [
            "001031751"
          ]
        },
        "TestName": {
          "description": "Client-facing, friendly name of a testing
admin/season/window.",
          "type": "string",
          "examples": [
            "MS Fall 2017 EOC"
          ]
        },
        "TestSubjectCode": {
          "description": "Internal identfier of subject/content area.",
          "type": "number",
          "examples": [
            "1004"
          ]
        },
        "SubjectName": {
          "description": "Client-facing, friendly name of
subject/content area.",
          "type": "string",
          "examples": [
            "English II"
          ]
```

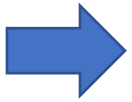


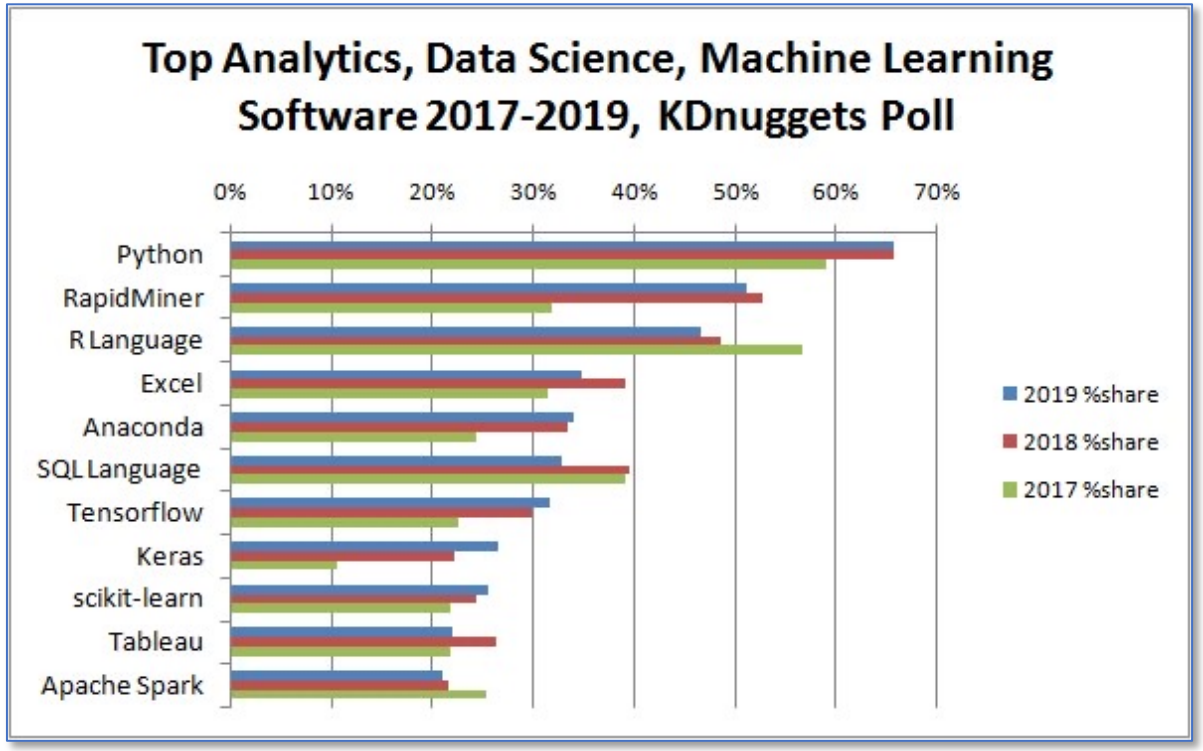
Table 3. *A schematic of the data frame converted from sequential data.*

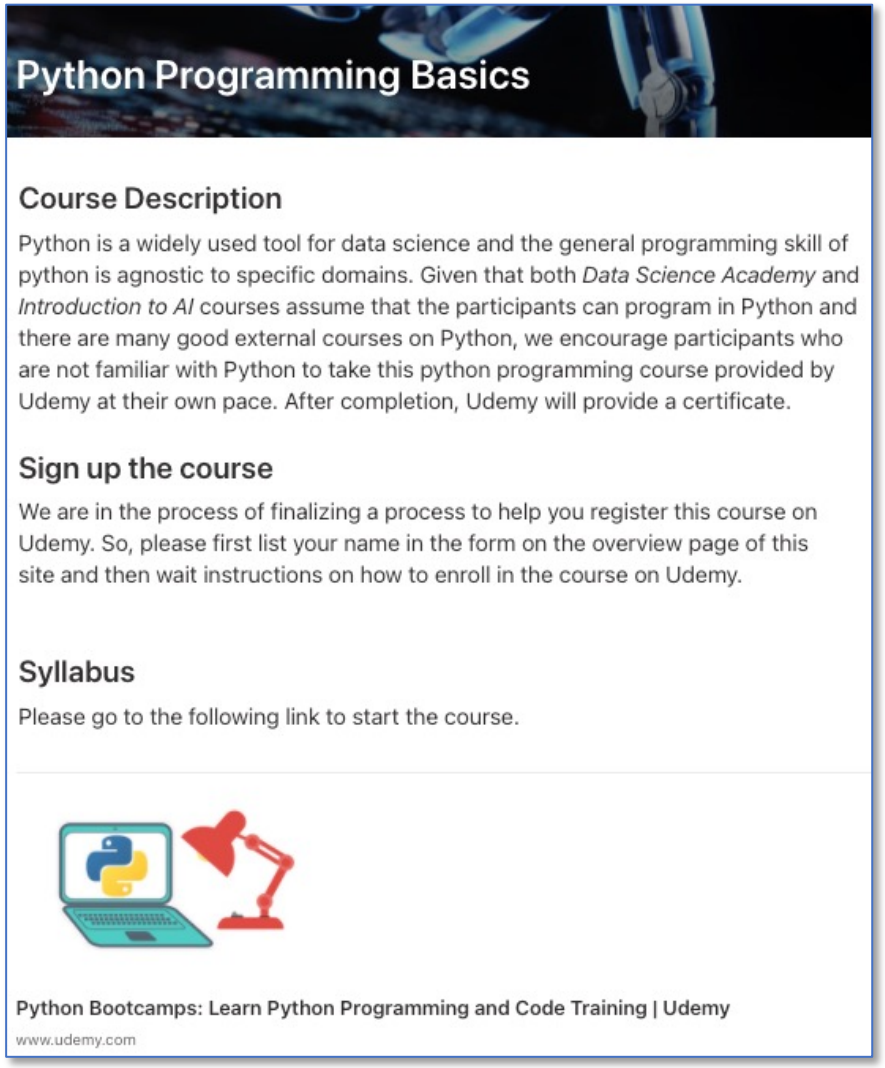
Sequence Number	*Event Time*	*Test Taker ID*	*Session ID*	*Event Name*	*Attribute 1*	*Attribute 2*	...
1	Timestamp 1	A	1	...	...	...	...
2	Timestamp 2	A	1	...	...	...	
3	...	A	1	...	...	...	...
4	...	A	1	...	...		
5	...	B	2	...	...	...	...
6	...	B	2	...	...	...	...
7	...	B	2	...	...	...	...

Hao & Mislevy, 2021

Data Science Tools

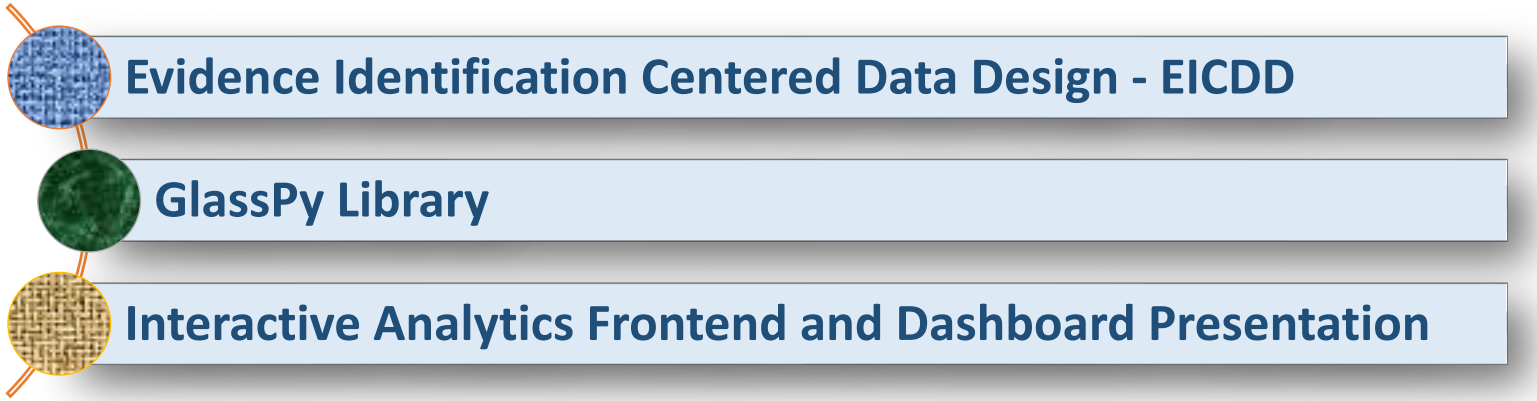
Survey from KDnuggets





GlassPy Analytics Solution at ETS

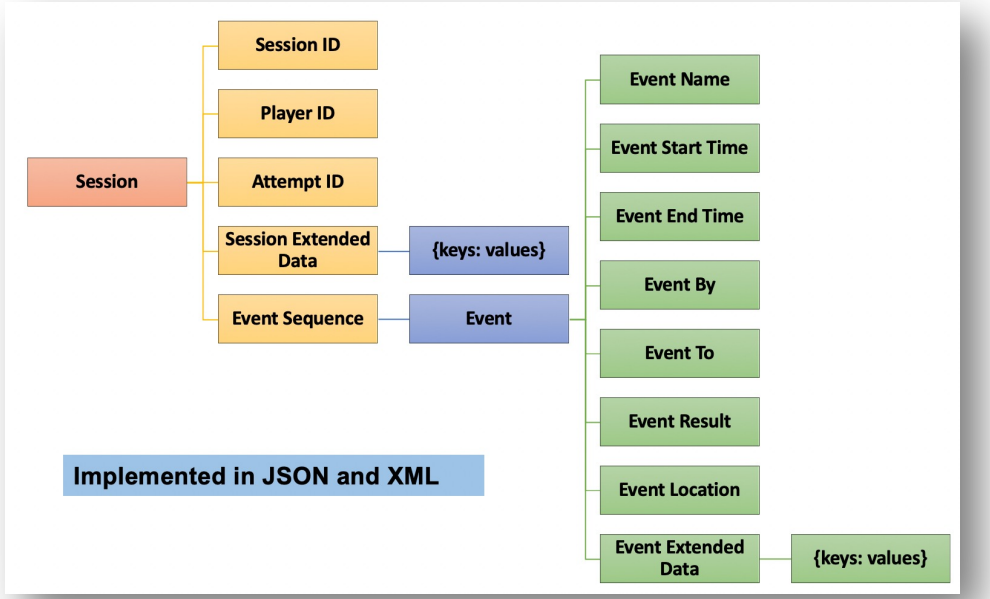
- GlassPy: Game Log Analysis in Python, started in 2014 at ETS
- We envision glassPy more as a generic framework for handling process data from digital-based assessments (DBAs)
- It is an "adaptor" to connect the Evidence Centered Design (ECD) to data in practice
- GlassPy analytics solution Includes three main components



Hao & Mislevy, 2021

Evidence Identification Centered Data Design

Data Model



Standard Operational Procedure

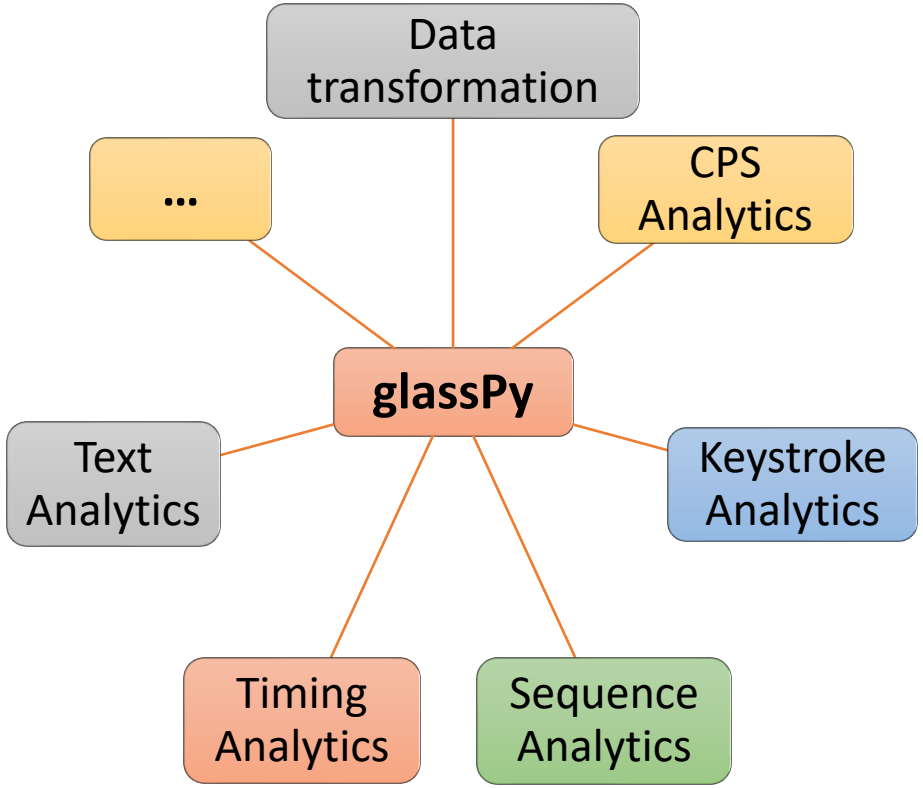
X: participant XX: coordinator

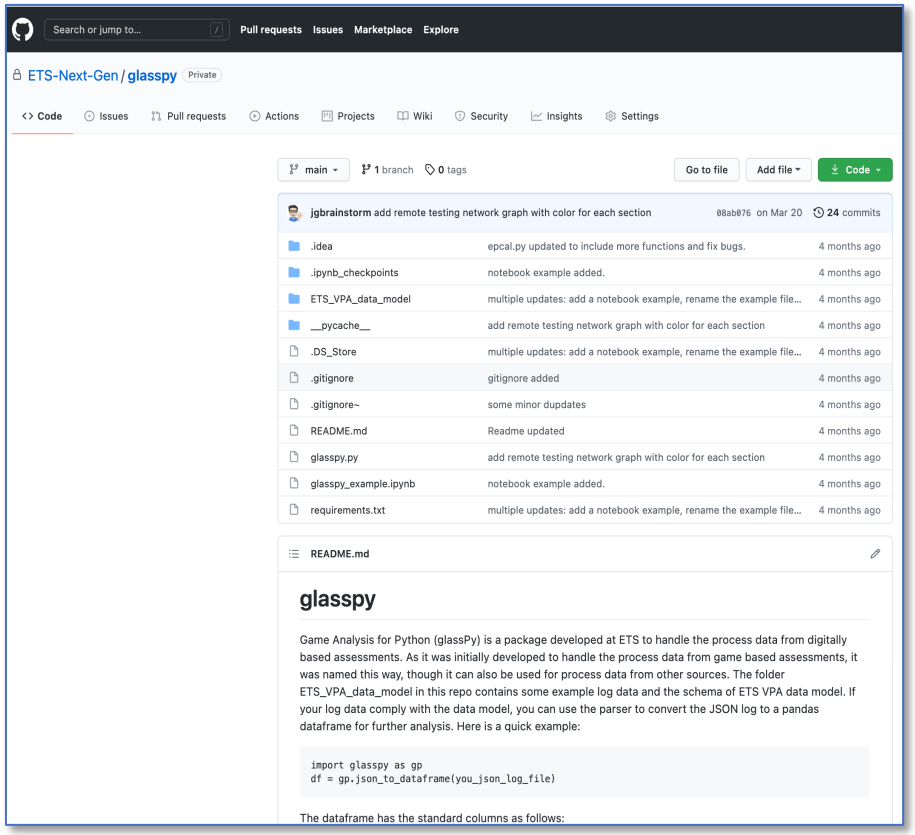
		Roles				
		Learning Scientist/ Assessment Developer	Psychometrician	Programmer	Data Scientist	Data analyst
Timeline	**Step 1**: All-party meeting to brief the procedures	X	X	X	XX	X
	Step 2: Specification of "Q matrix" for constructs and evidences	X				
	Step 3: Specification of additional evidence for psychometric modeling need		X			
	Step 4: Translate the evidences into operable task codes			X	X	XX
	Step 5: Design log file structure and schema				X	
	Step 6: Implement the evidence logging into the log file and tryout			X	X	XX
	Step 7: Log file parsing and evidence extraction based on the tryout data				X	
	Step 8: QA the log files to check whether the recovered evidence is sufficient. If not, restart from **Step 6**. If everything is good, proceed to next step	X	X		X	XX
	Step 9: Finalize the data reduction pipeline and QA procedure				XX	X
	Step 10: Implement the data reduction				X	XX

Evidence Trace File

Hao et al., 2016; Hao & Mislevy, 2018; 2021

GlassPy Library

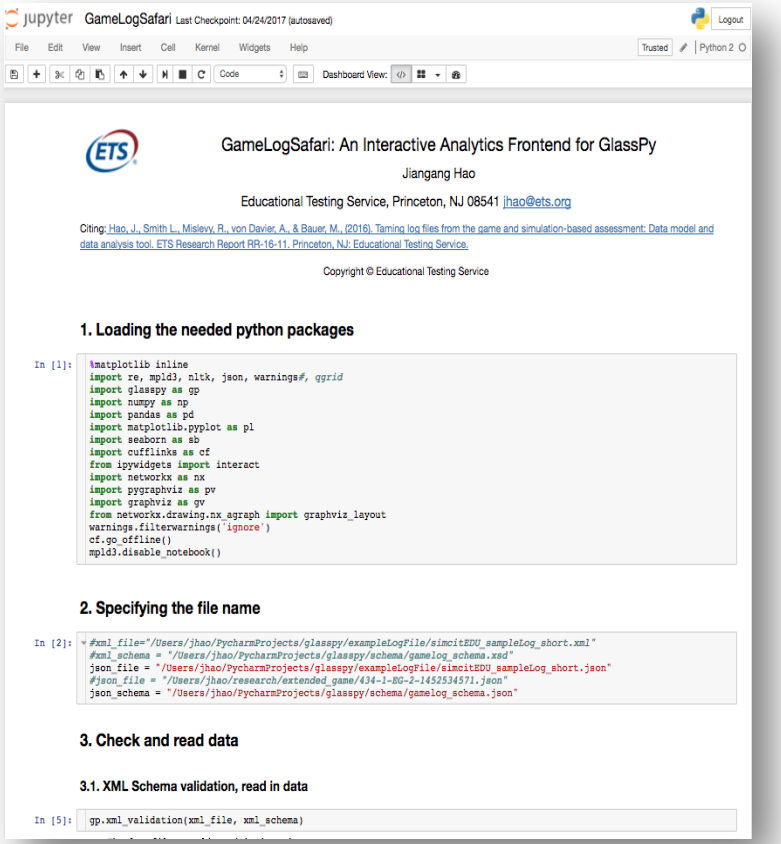


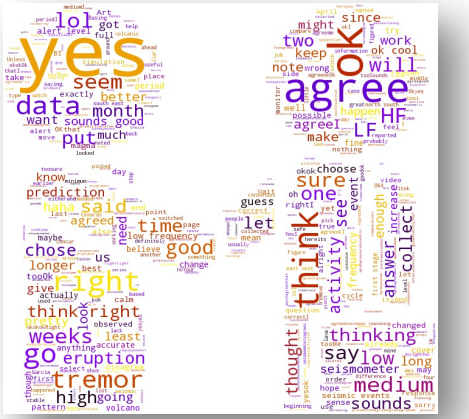


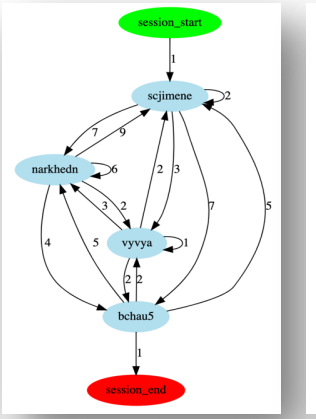
Not open sourced yet and under active expanding

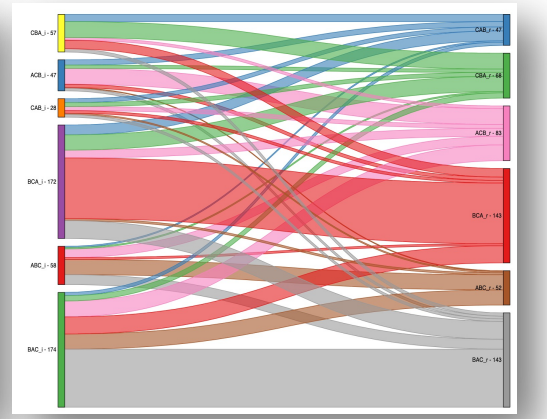
Interactive Analytics Frontend

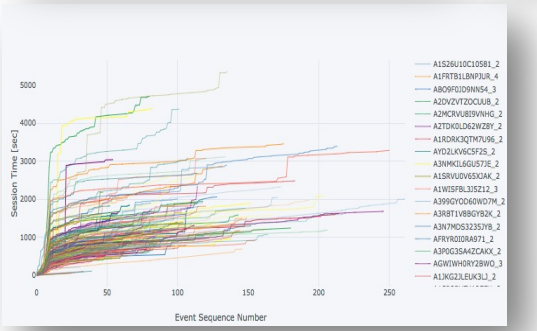
Jupyter/Zeppelin Notebook/Lab + Plotly Dash/Shiny /Streamlit+ FastAPI/Flask+ others

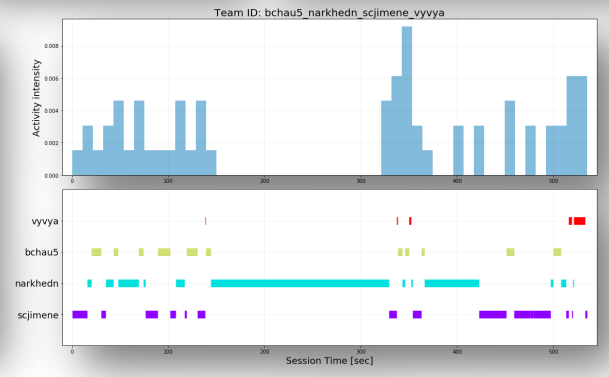








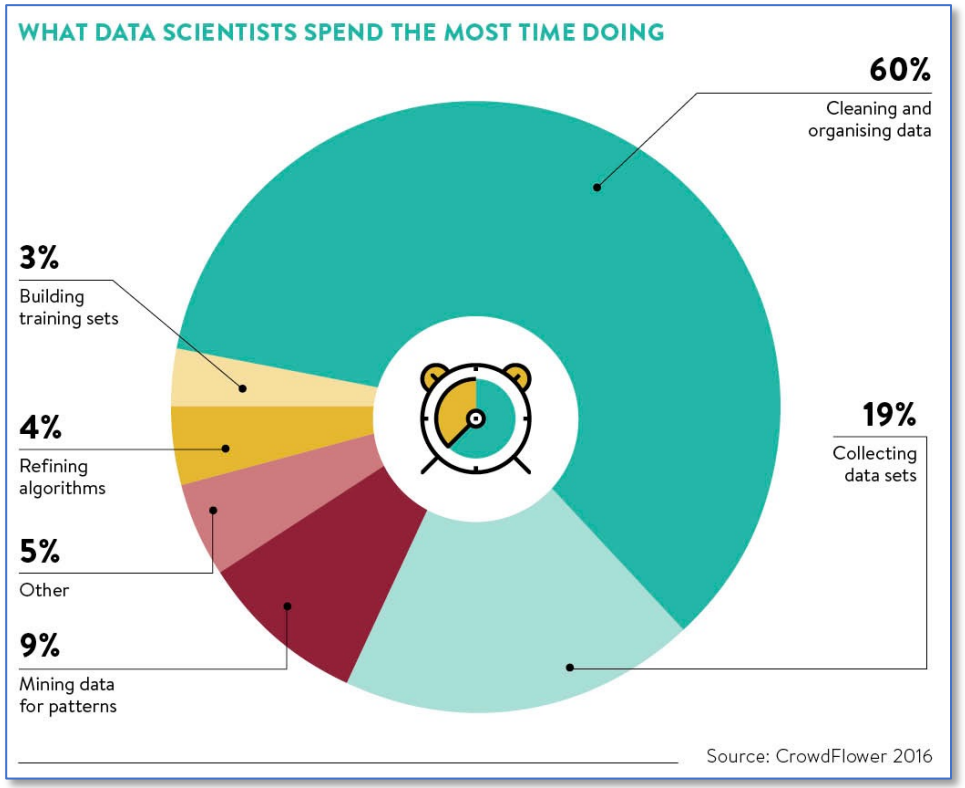




Summary

Take Home Message

- Data science is a teamwork, so choose the most suitable workflow for your project and your team.
- Getting data ready takes efforts, put deadlines for different deliverables.
- Spending time to plan the work will NOT slow you down
- Making sense of data is more an art than science!



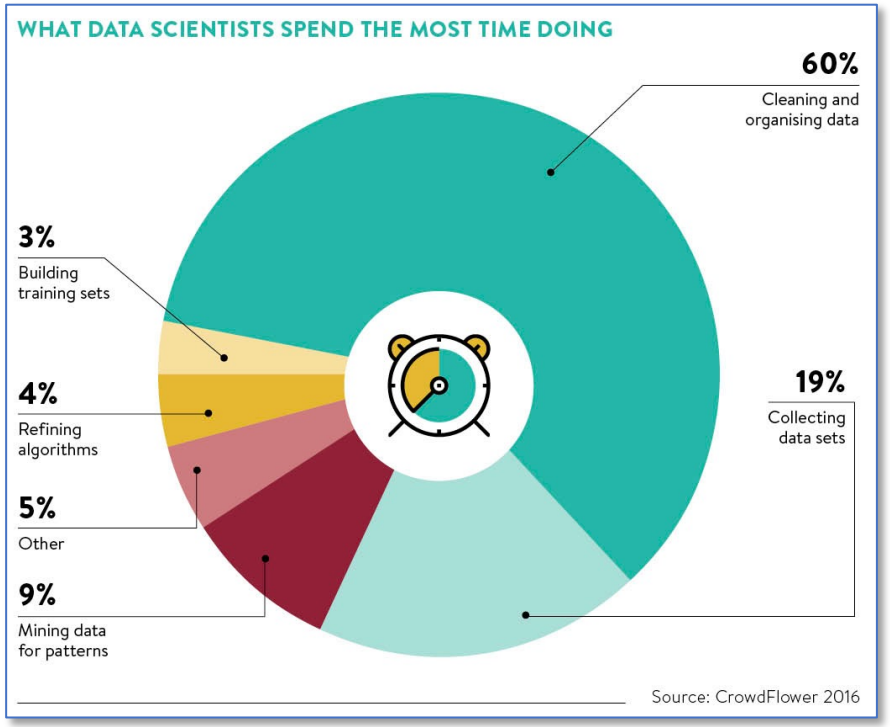
Data Wrangling

What is Data Wrangling

Data Wrangling

Data wrangling, also known as data munging, is the process of transforming and mapping data from one “raw” format into another format with the intent of making it more appropriate and valuable for a variety of downstream purposes such as analytics

- Wikipedia



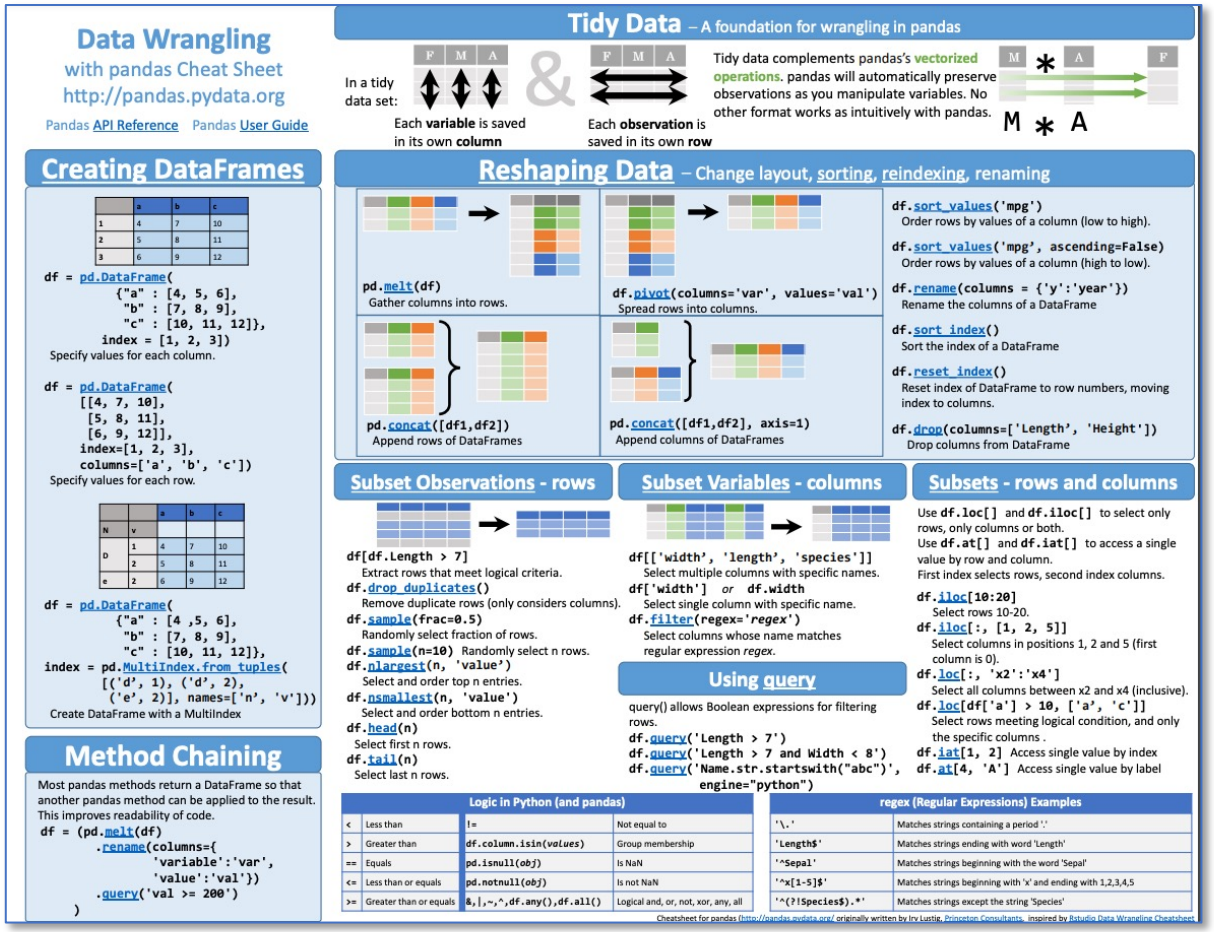
Types of Raw Data

- **Unstructured data**: information that either does not have a predefined data model or is not organized in a pre-defined manner
- **Structured data**: information created by following a predefined data model
- **Semi-structured data** is a form of structured data that does not obey the tabular structure of data models associated with relational database or other forms of data tables, but nonetheless contains tags or other markers to separate semantic elements and enforce hierarchies of records and fields within the data. Therefore, it is also known as self-describing structure.
  - HTML, XML, JSON, YAML, etc.

Pandas for Tabular Data Wrangling and Analysis

pandas

Original author(s)	Wes McKinney
Developer(s)	Community
Initial release	11 January 2008; 13 years ago[*citation needed*]
Stable release	1.3.0[1] / 2 July 2021; 3 months ago
Repository	github.com/pandas-dev/pandas
Written in	Python, Cython, C
Operating system	Cross-platform
Type	Technical computing
License	New BSD License
Website	pandas.pydata.org



https://pandas.pydata.org/Pandas_Cheat_Sheet.pdf

Unstructured Data

Unstructured text file

```
[5/15/2013 2:17:26 PM] Session Start
[5/15/2013 2:17:26 PM] Leaving sequence: loadXML, moving forward.
[5/15/2013 2:17:30 PM] Player submitted name: Carl
[5/15/2013 2:17:30 PM] Leaving sequence: InputNameScreen, moving forward.
[5/15/2013 2:17:31 PM] Player submitted name: Carl
[5/15/2013 2:17:31 PM] Leaving sequence: startScreen, moving forward.
[5/15/2013 2:17:50 PM] Player submitted name: Carl
[5/15/2013 2:17:50 PM] Leaving sequence: slide2, moving forward.
[5/15/2013 2:17:55 PM] Player submitted name: Carl
[5/15/2013 2:17:55 PM] Leaving sequence: slide2b, moving forward.
[5/15/2013 2:18:34 PM] Player submitted name: Carl
[5/15/2013 2:18:34 PM] Leaving sequence: slide2c, moving forward.
[5/15/2013 2:20:09 PM] Player submitted name: Carl
[5/15/2013 2:20:09 PM] Leaving sequence: slide3, moving forward.
[5/15/2013 2:20:13 PM] Player submitted name: Carl
[5/15/2013 2:20:13 PM] Leaving sequence: slide4, moving forward.
```

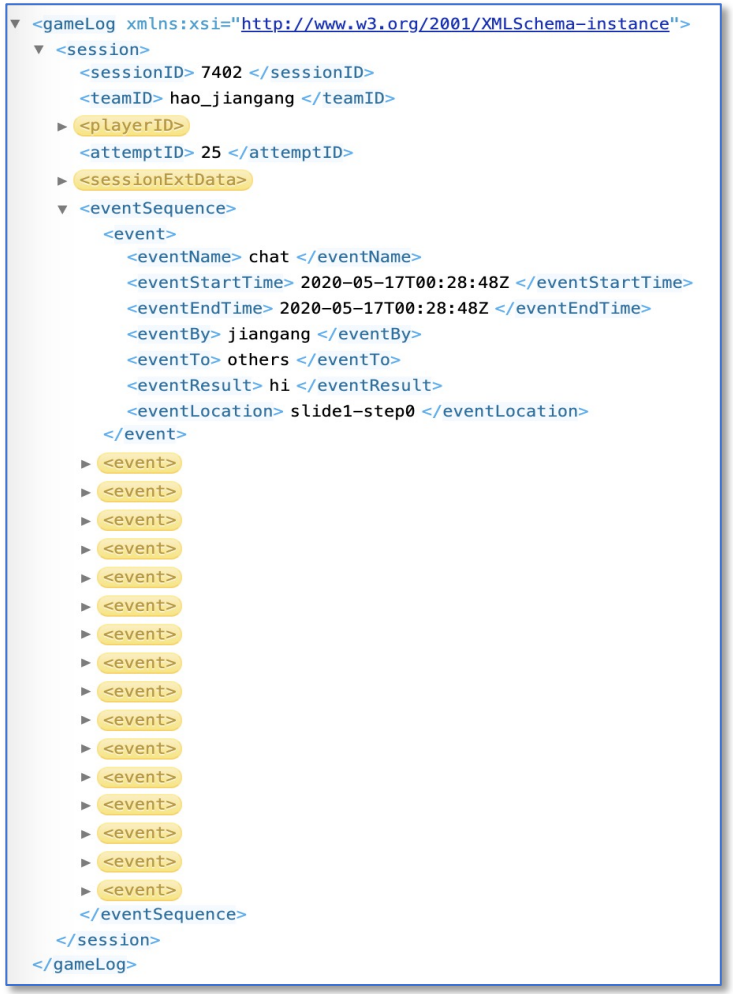
Demo of parsing unstructured file using Python

Structured Data

XML, JSON

XML – Extensible Markup Language

- XML –W3C 1998
- Markup and contents
  - <start_time> 10:10 </start_time>
  - <![CDATA[this is the comments]]>
- Tag
  - Start-tag <shape>
  - End-tag </shape>
  - Empty-tag <shape/>
- Elements
  - <start_time> 10:10 </start_time>
- Attributes: name-value pair
  - <start_time timezone="EST"> 10:10 </start_time>
- Declaration: <?xml version="1.0" encoding="UTF-8"?>

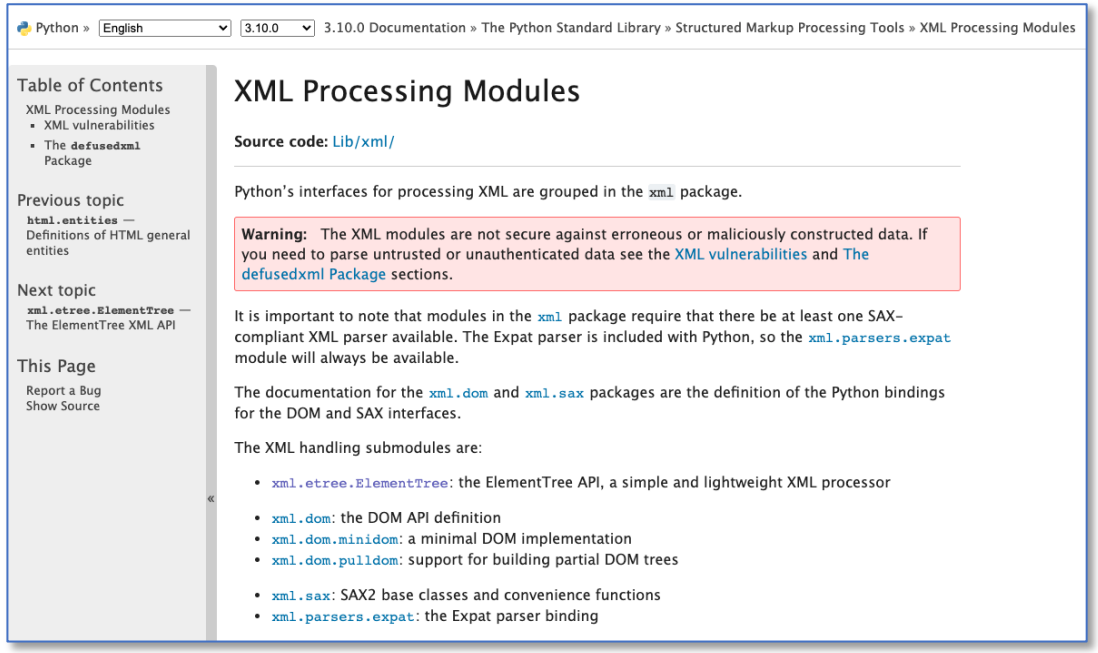


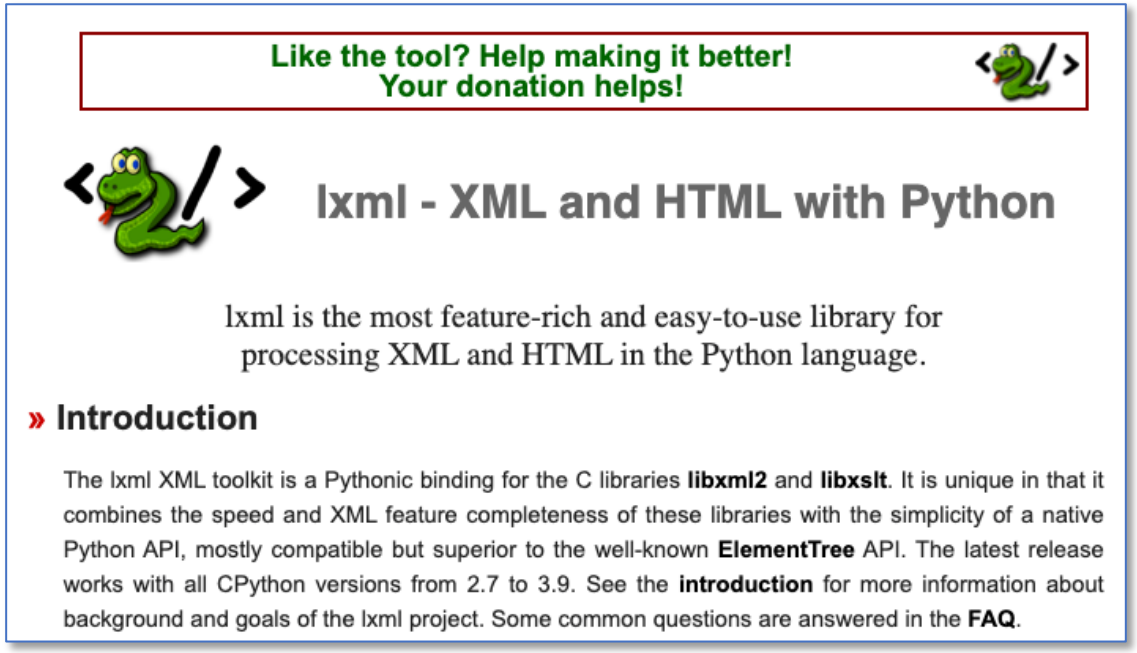
Data from EPCAL

https://www.w3schools.com/xml/

Python Tool for XML

- "Official" XML library: https://docs.python.org/3/library/xml.html
- LXML: https://lxml.de/





JSON

JavaScript Object Notation

Filename extension	`.json`
Internet media type	`application/json`
Type code	TEXT
Uniform Type Identifier (UTI)	public.json
Type of format	Data interchange
Extended from	JavaScript
Standard	STD 90 (RFC 8259), ECMA-404, ISO/IEC 21778:2017
Open format?	Yes
Website	json.org

Introduced in 2000


```
{
 - gameLog: [
    - {
           sessionID: "7402",
         + playerID: [2],
         + sessionExtData: {4},
         - eventSequence: [
            - {
                  eventName: "chat",
                  eventStartTime: "2020-05-17T00:28:48Z",
                  eventEndTime: "2020-05-17T00:28:48Z",
                  eventBy: "jiangang",
                  eventTo: "others",
                  eventResult: "hi",
                  eventLocation: "slide1-step0",
                  eventExtData: { },
              },
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
            + {8},
           ],
           teamID: "hao_jiangang",
           attemptID: 25,
       }
   ]
}
```


Valid Data Types

In JSON, values must be one of the following data types:

- a string
- a number
- an object (JSON object)
- an array
- a boolean
- *null*

JSON values **cannot** be one of the following data types:

- a function
- a date
- *undefined*

https://www.w3schools.com/js/

JSON vs. XML

JSON is Like XML Because

- Both JSON and XML are "self describing" (human readable)
- Both JSON and XML are hierarchical (values within values)
- Both JSON and XML can be parsed and used by lots of programming languages
- Both JSON and XML can be fetched with an XMLHttpRequest

JSON is Unlike XML Because

- JSON doesn't use end tag
- JSON is shorter
- JSON is quicker to read and write
- JSON can use arrays

The biggest difference is:

XML has to be parsed with an XML parser. JSON can be parsed by a standard JavaScript function.

Why JSON is Better Than XML

XML is much more difficult to parse than JSON.
JSON is parsed into a ready-to-use JavaScript object.

Both XML and JSON are widely used for instantiation of document data models

Schema: Define and Validate Data

XML Schema

- XML schema: define the structure and data type of a xml file
- Practical use: validation- comparing the xml file to the schema to check for compliance

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified">

<!--
  Game Log Schema
  Version 2.0
  Authors:
    Lonnie Smith (lsmith@ets.org)
    Jiangang Hao (jhao@ets.org)

    Note: this is the final version as of 7/27/2015

    (c) 2014, Educational Testing Service
-->

  <!-- Root element and children -->

  <xs:element name="gameLog">
    <xs:complexType>
      <xs:sequence>
              <xs:element name="session" minOccurs="1" maxOccurs="unbounded">
                <xs:complexType>
                  <xs:sequence>
                    <xs:element name="sessionID" type="idType" minOccurs="1" maxOccurs="1"/>
                    <xs:element name="teamID" type="idType" minOccurs="1" maxOccurs="1"/>
                    <xs:element name="playerID" type="dictType" minOccurs="1" maxOccurs="1"/>
                    <xs:element name="attemptID" type="idType" minOccurs="1" maxOccurs="1"/>
                    <xs:element name="sessionExtData" type="dictType" minOccurs="0" maxOccurs="1"/>
                    <xs:element name="eventSequence" minOccurs="1" maxOccurs="1">
                      <xs:complexType>
                        <xs:sequence>
                          <xs:element name="event" type="eventType" minOccurs="1" maxOccurs="unbounded"/>
                        </xs:sequence>
                      </xs:complexType>
                    </xs:element>
                  </xs:sequence>
                </xs:complexType>
              </xs:element>
      </xs:sequence>
    </xs:complexType>
  </xs:element>


  <!-- Data type definitions -->


  <!-- ID definition. All identifiers must follow this rule -->
  <xs:simpleType name="idType">
    <xs:restriction base="xs:string">
      <xs:pattern value="[a-zA-Z0-9_\-]{1,}"/>
    </xs:restriction>
  </xs:simpleType>


  <!-- Timestamps must follow subset of ISO 8601 standard, be resolved to (at least) the milisecond, and must use UTC -->
  <xs:simpleType name="timestampType">
    <xs:restriction base="xs:dateTime">
      <xs:pattern value="20\d{2}-\d{2}-\d{2}T\d{2}:\d{2}:\d{2}Z"/>
    </xs:restriction>
  </xs:simpleType>
```

Example schema from ETS VPA data model

JSON Schema

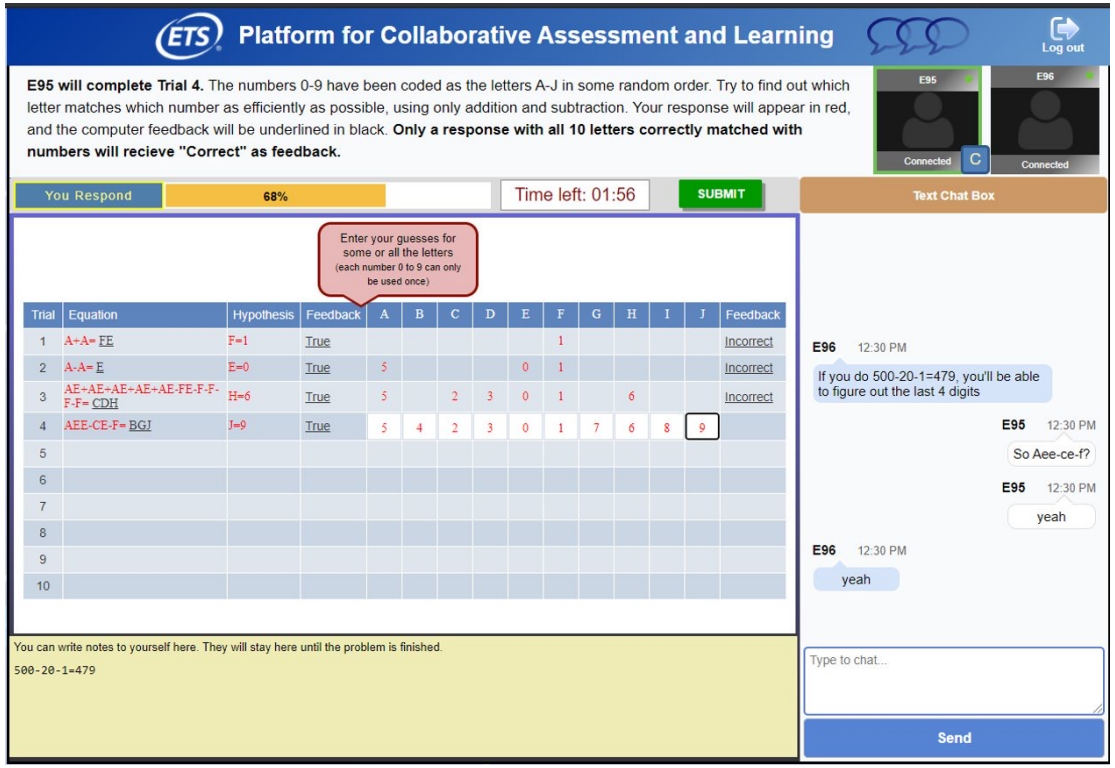
- Define JSON file/string
- Can be used to validate JSON file

```
{
  "$schema": "http://json-schema.org/draft-04/schema#",
  "description":"Gamelog Schema v1.2, Created by Jiangang Hao @ ETS",
  "type": "object",
  "properties": {
    "gameLog": {
      "type": "array",
      "items": {
        "type": "object",
        "properties": {
          "sessionID": {
              "type": "string",
          "pattern":"[a-zA-Z0-9_\\-]{1,}"
          },
          "playerID": {
              "type": "string",
          "pattern":"[a-zA-Z0-9_\\-]{1,}"
          },
          "attemptID": {
            "type": "integer"
          },
          "sessionExtData": {
            "type": "object"
          },
          "eventSequence": {
            "type": "array",
            "items": {
              "type": "object",
              "properties": {
                "eventName": {
                    "type": "string",
            "pattern":"[a-zA-Z0-9_\\-]{1,}"
                },
                "eventStartTime": {
                    "type": "string",
            "pattern":"20\\d{2}-\\d{2}-\\d{2}T\\d{2}:\\d{2}:\\d{2}Z"
                },
                "eventEndTime": {
                    "type": "string",
            "pattern":"20\\d{2}-\\d{2}-\\d{2}T\\d{2}:\\d{2}:\\d{2}Z"
                },
```

Demo of parsing structured file using Python

Hands-on Exercise

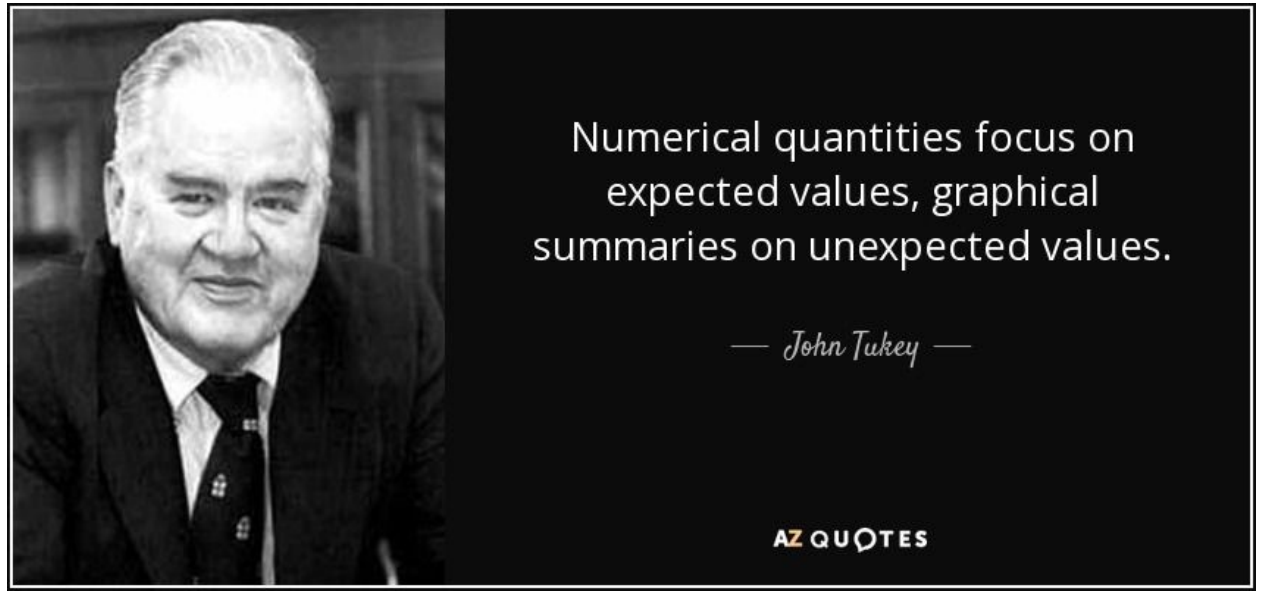
Lab Study– Data from ETS VPA

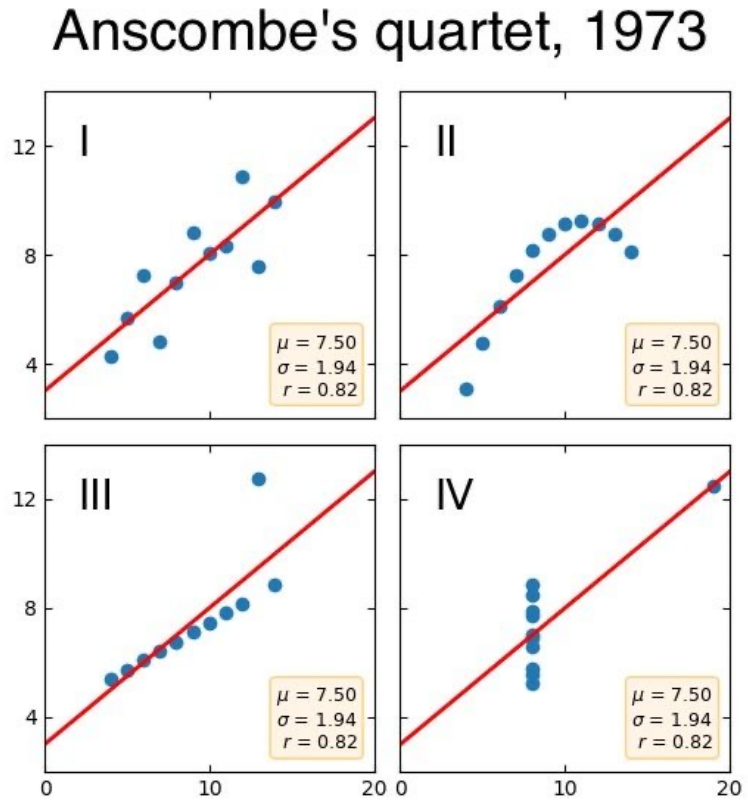



```
0:
  sessionID:          "7369"
  teamID:             "hao_jiangang"
  playerID:           […]
  attemptID:          17
  sessionExtData:     {…}
  eventSequence:
    0:
      eventName:      "chat"
      eventStartTime: "2019-11-06T14:18:31Z"
      eventEndTime:   "2019-11-06T14:18:31Z"
      eventBy:        "jiangang"
      eventTo:        "others"
      eventResult:    "hi"
      eventLocation:  "slide1-step0"
      eventExtData:   {}
    1:
      eventName:      "question"
      eventStartTime: "2019-11-06T14:18:42Z"
      eventEndTime:   "2019-11-06T14:18:42Z"
      eventBy:        "jiangang"
      eventTo:        "cbal-1-0"
      eventResult:    "1"
      eventLocation:  "slide2-step0"
      eventExtData:   {}
    2:
      eventName:      "question"
      eventStartTime: "2019-11-06T14:18:42Z"
      eventEndTime:   "2019-11-06T14:18:42Z"
      eventBy:        "jiangang"
      eventTo:        "cbal-1-1"
      eventResult:    "dfsa"
      eventLocation:  "slide2-step0"
      eventExtData:   {}
```

Data Visualization

Visualization is Important





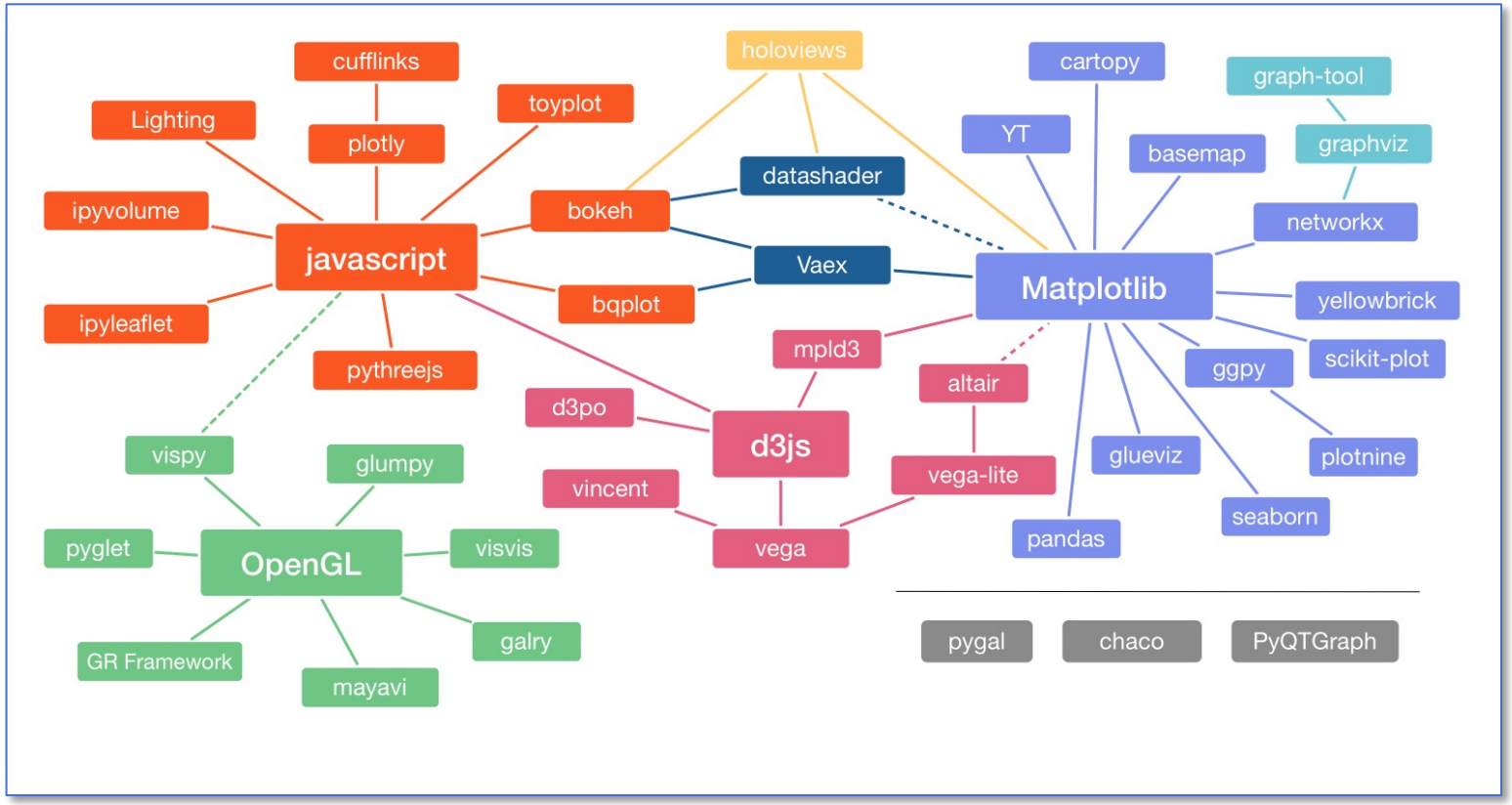
Steps to Visualization

- Understand the nature of your data
  - Categorical/continuous
  - Sparse
- Understand your goals
  - Audience
  - Production/exploration?
  - Interactivity required?
- Plan the types of visualizations you'll create
  - Scatter plot, distribution, dendrogram, etc.
- Choose a visualization framework(s)
- Do it!

https://chart.guide/topics/chartguide-poster-4-0/

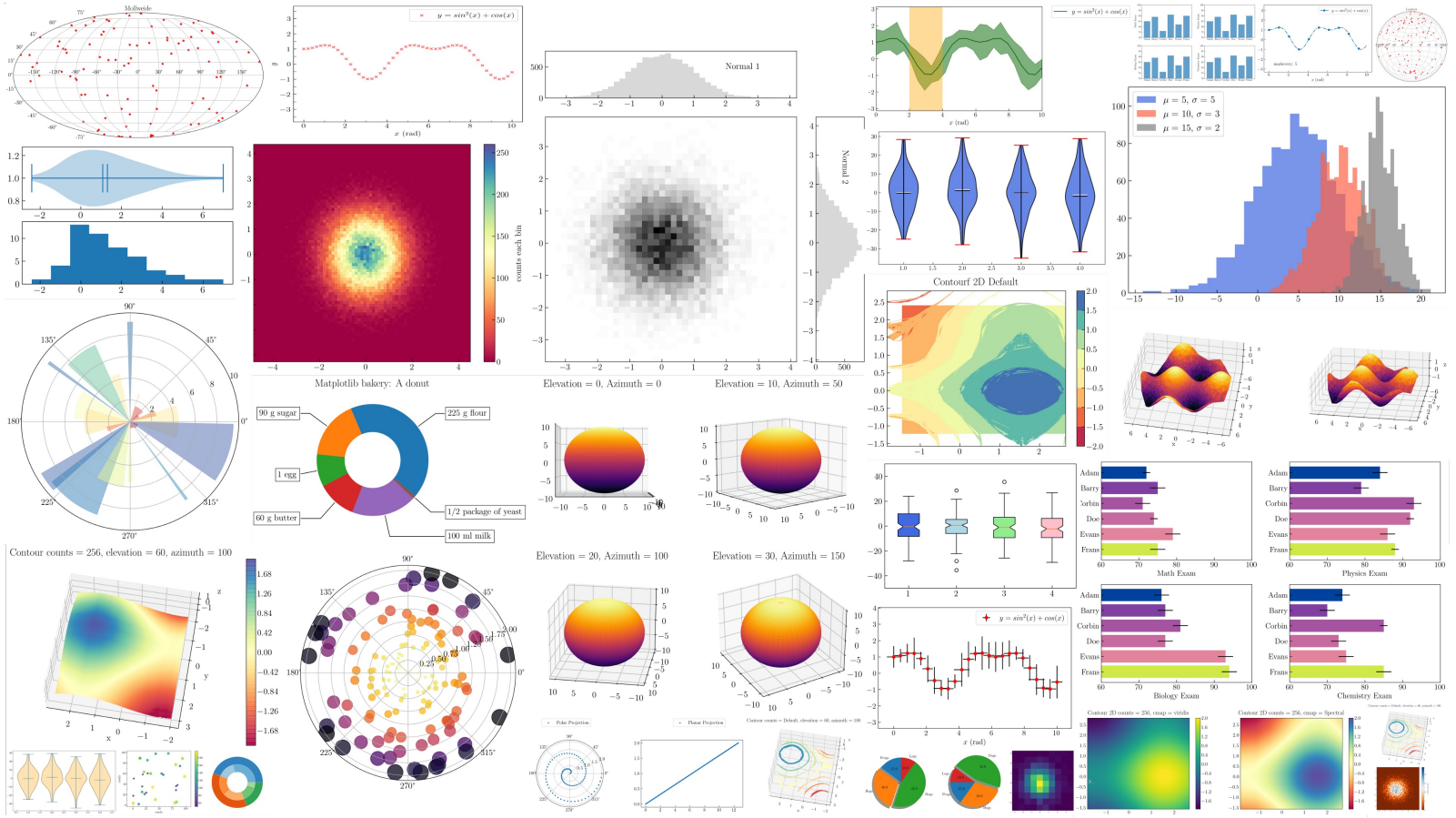
Visualization in Python

- PyViz is your gateway: www.pyviz.org
- Visualization paradigms



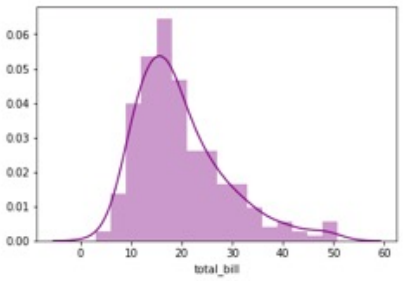
Matplotlib

https://matplotlib.org/

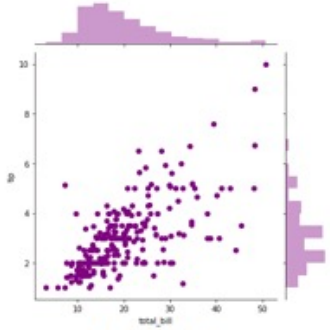


Seaborn: built on top of matplotlib

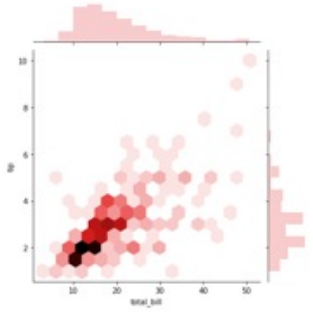
https://seaborn.pydata.org/



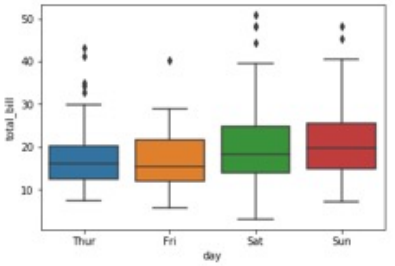
distplot



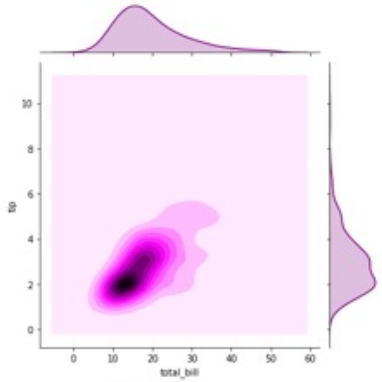
Jointplot



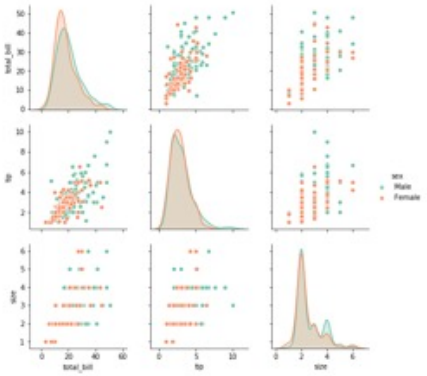
Hexplots



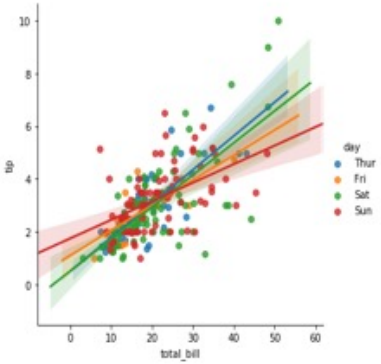
Boxplots



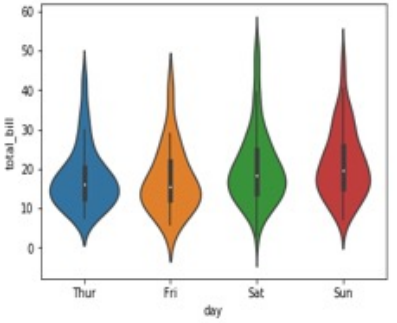
KDE Plot



Pair Plots



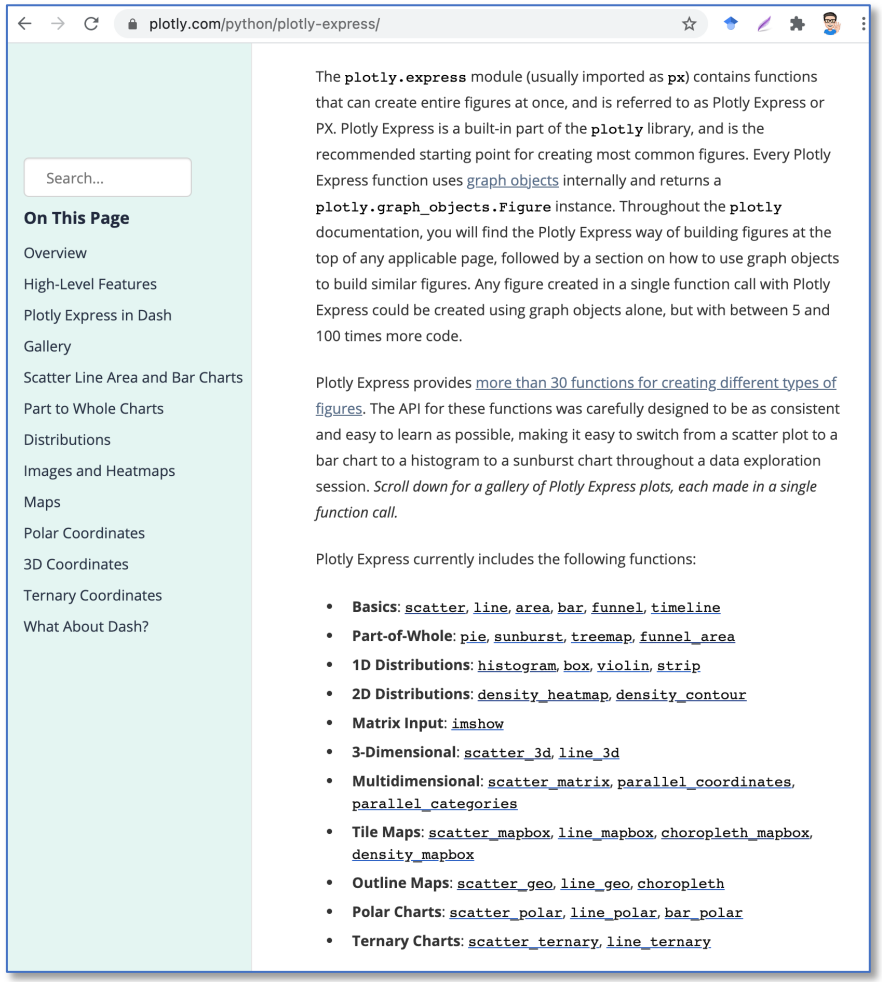
LM Plots

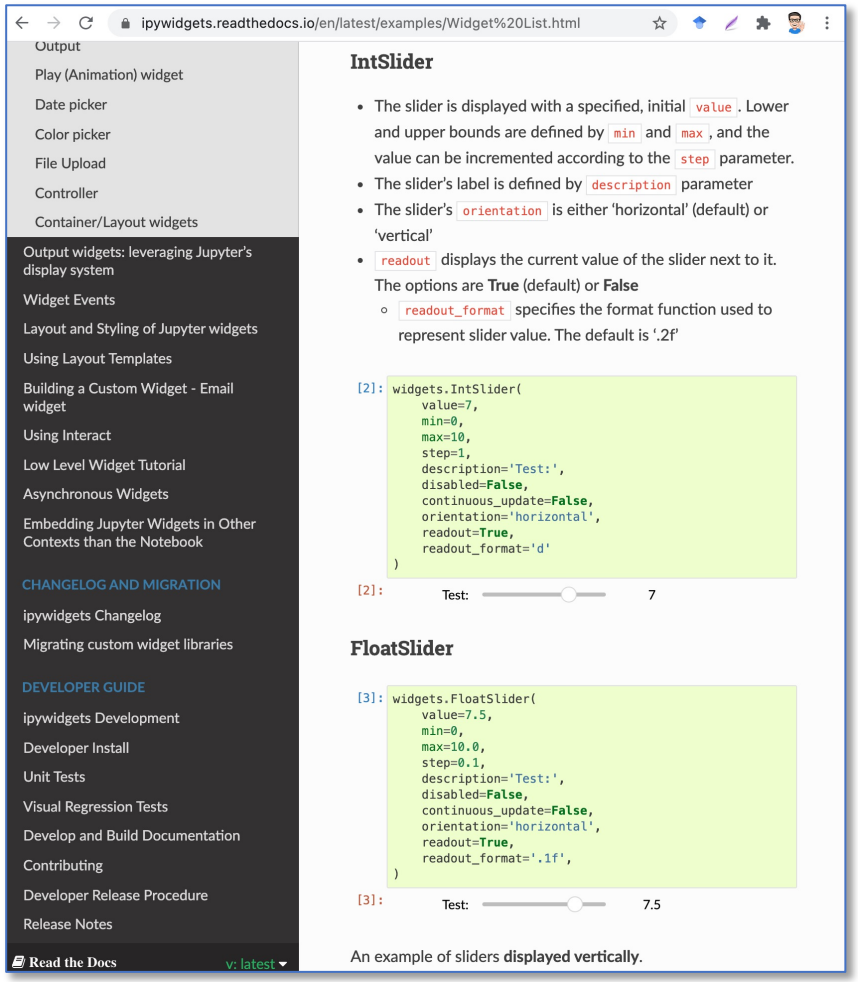


Violin Plots

Interactive Visualization

Plotly Express and ipywidgets

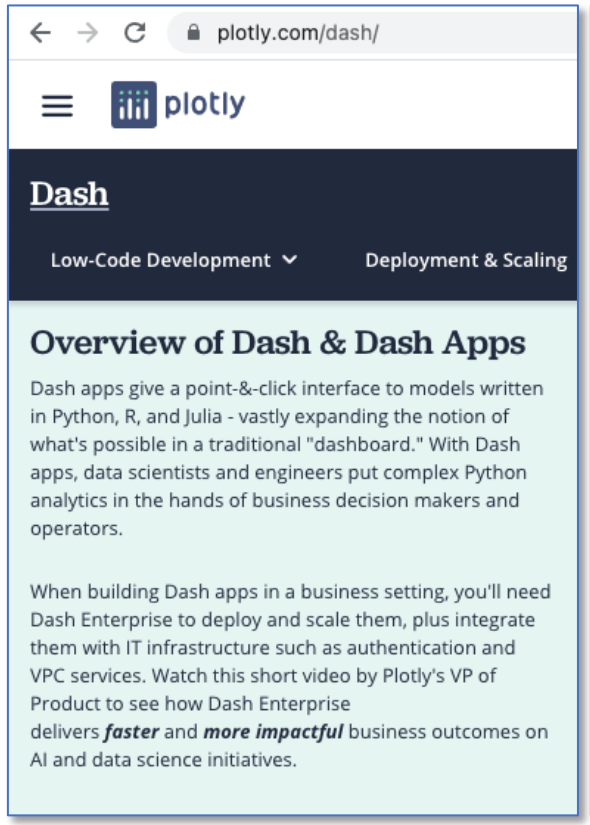


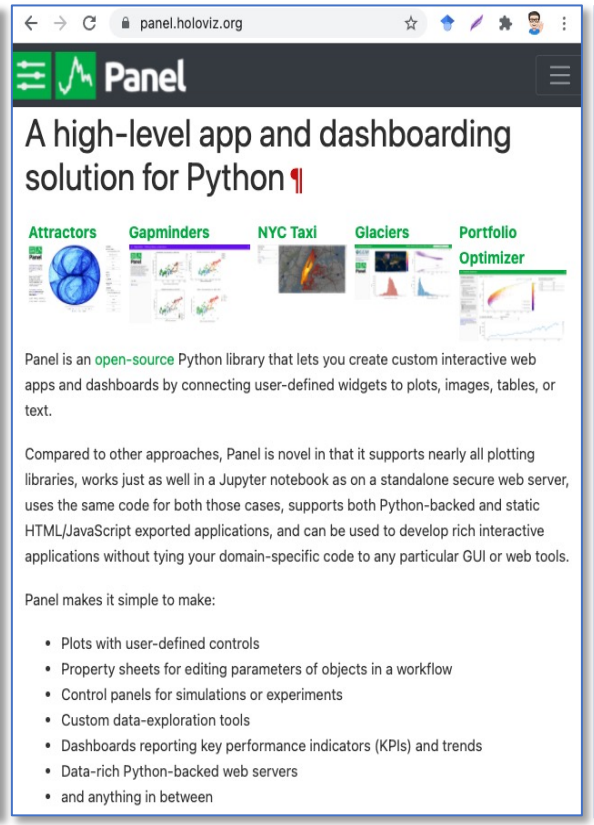


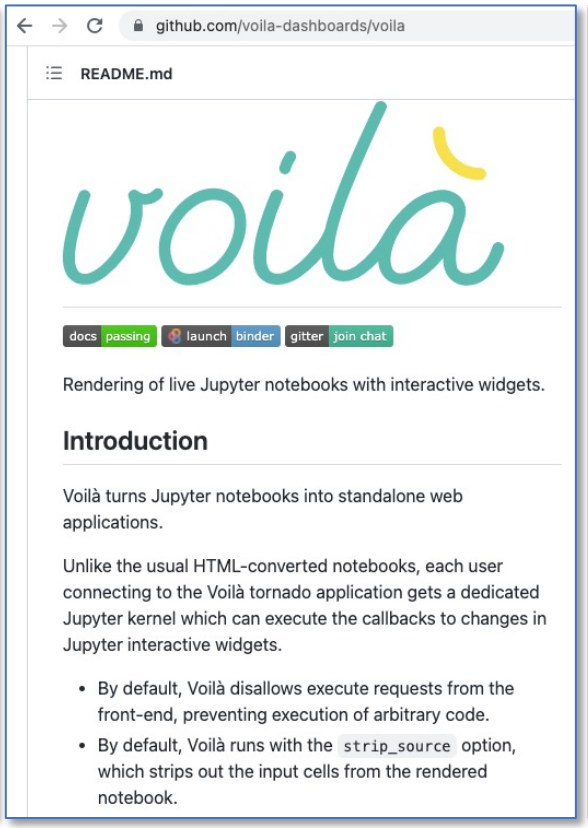
Demos

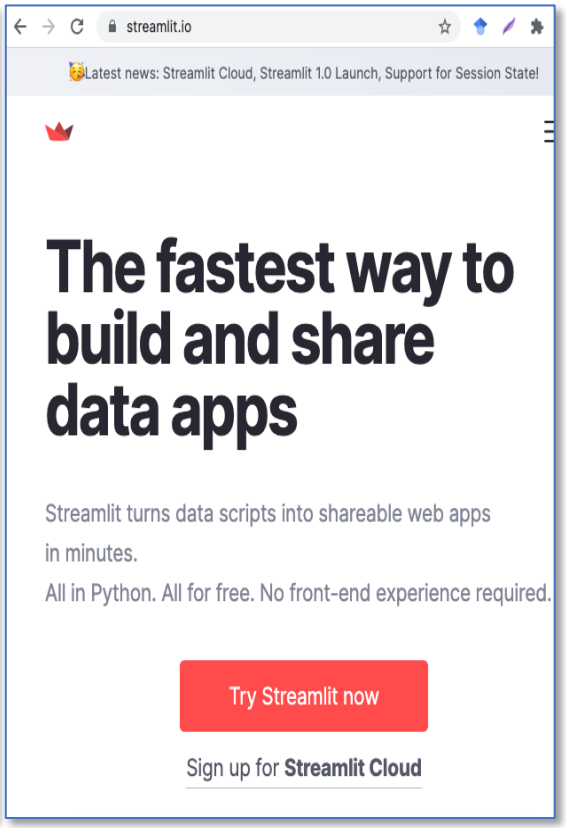
Dashboarding

Major Dashboard Tools in Python



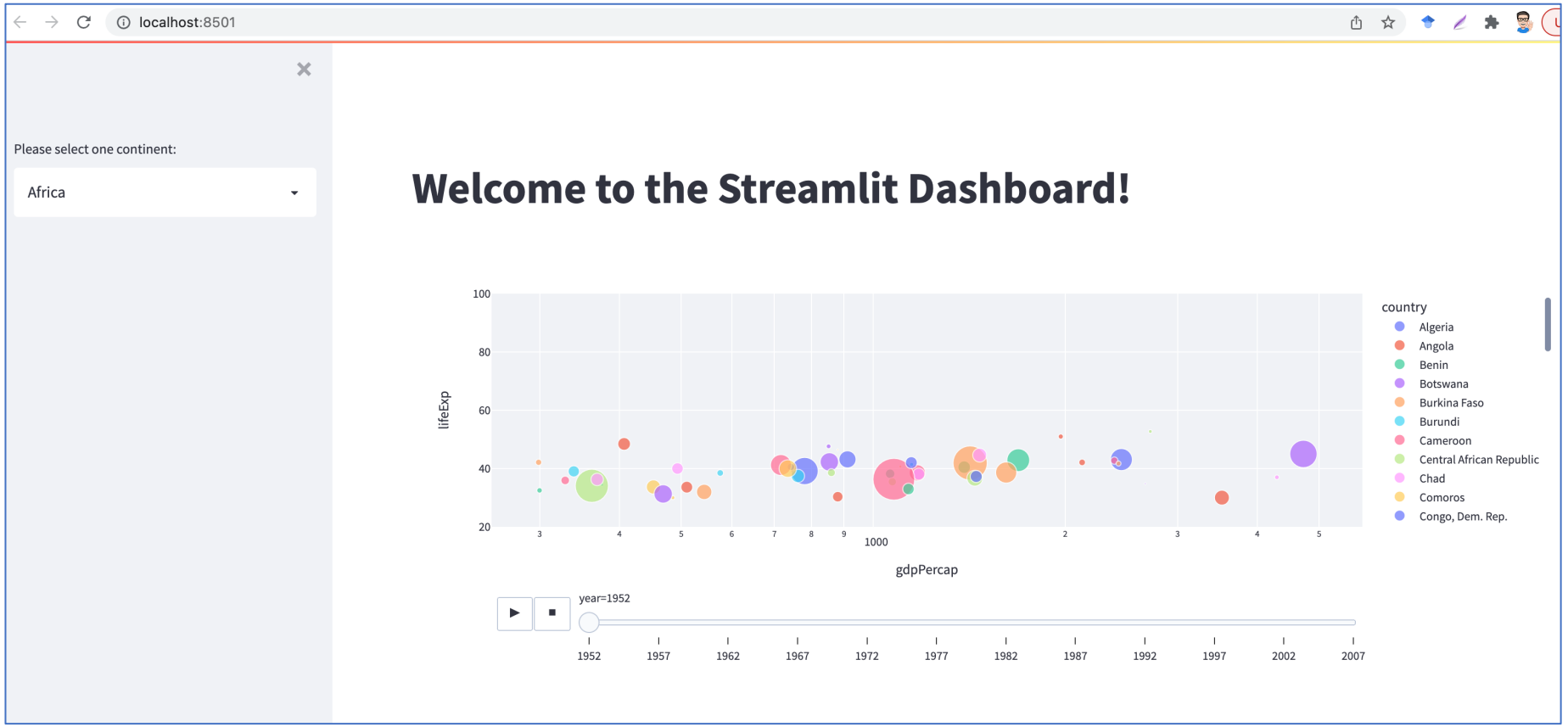






They are kind of equivalent to the Shiny package in R

Examples



Demo

Hands-on Lab

Lab

- Create visualizations using matplotlib, seaborn, plotly and ipywidgets using the dataset
  - Histogram, scatter plot, pie, others
- Create one streamlit dashboard