NRC·CNRC

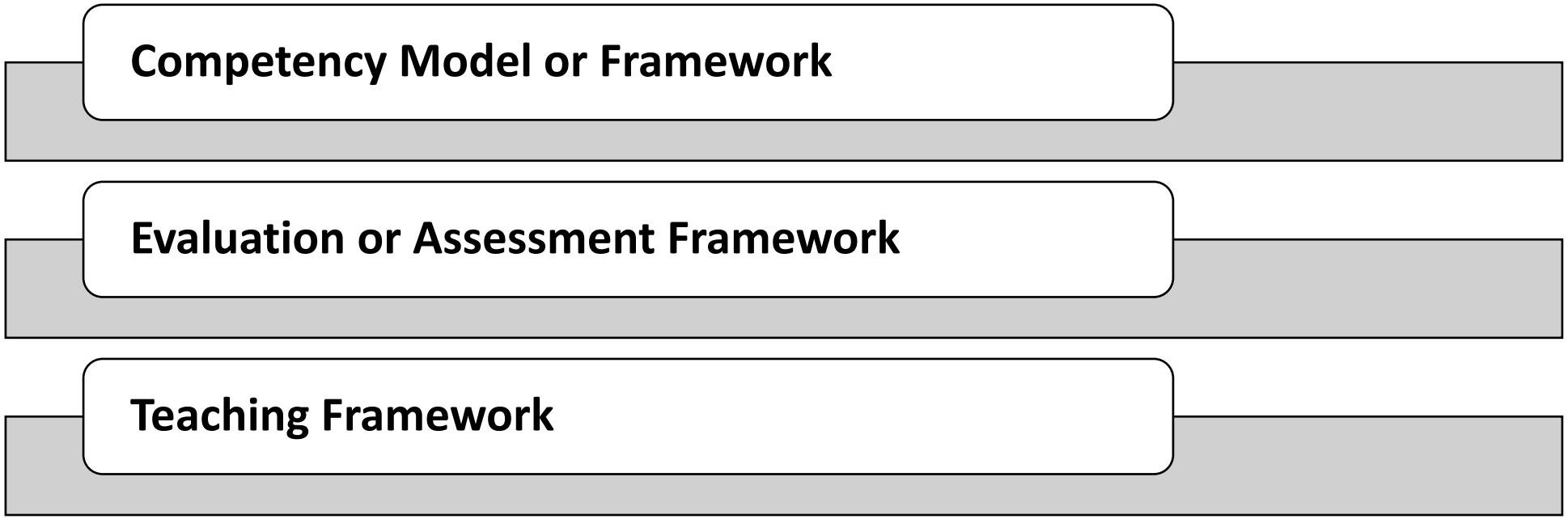
NRC.CANADA.CA

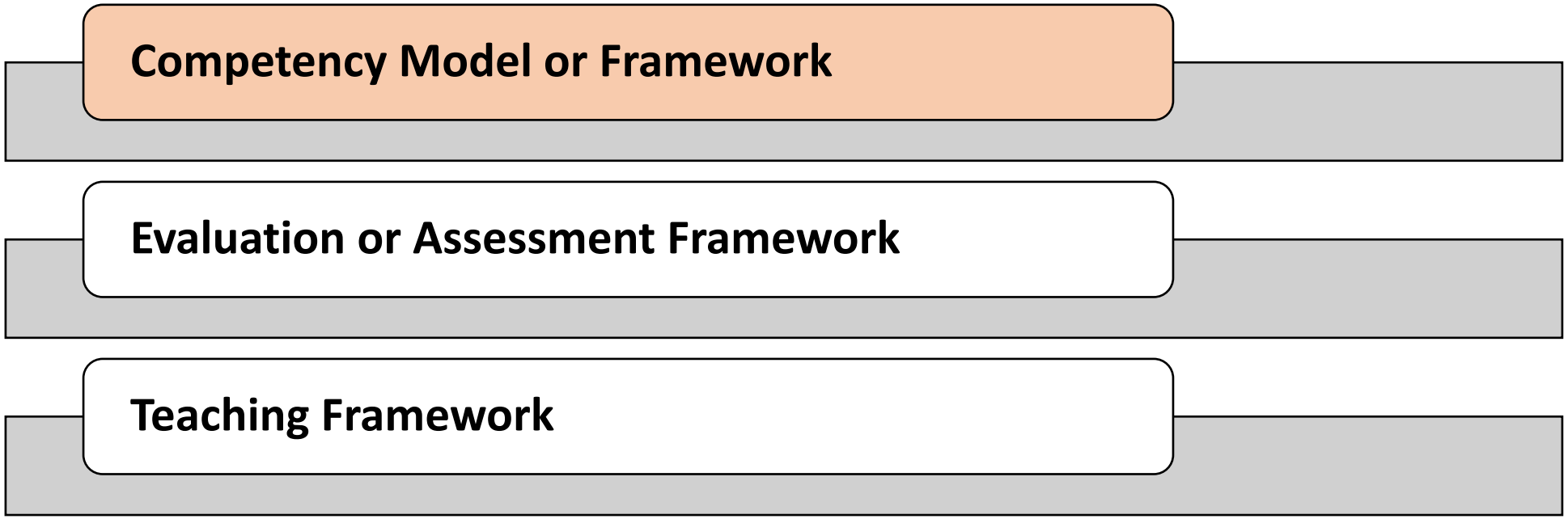
Data Literacy

Models, Assessment, and Development

Stephen Downes
March 28, 2022

Three Frameworks

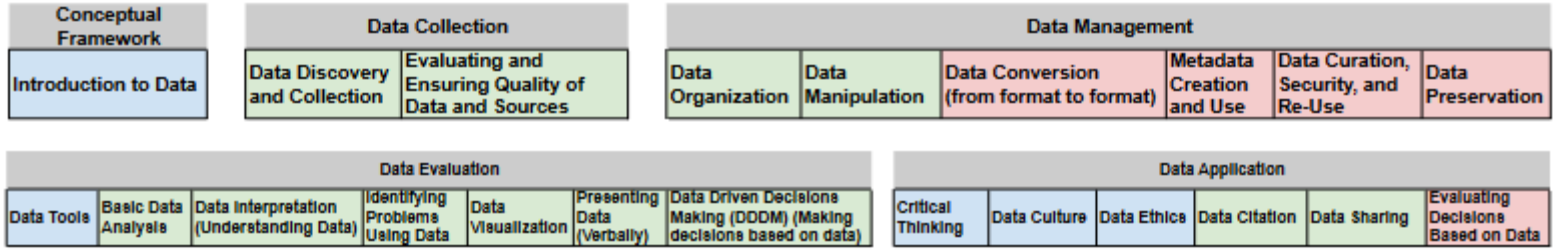



Competency Model or Framework
Evaluation or Assessment Framework
Teaching Framework

Defining Data Literacy

“Data literacy is the ability to collect, manage, evaluate, and apply data, in a critical manner” (p. 2).

“We define the core skills and competencies that comprise data literacy, using a thematic analysis of the elements of data literacy described in peer-reviewed literature. These competencies (23 in total) and their skills, knowledge, and expected tasks (64 in total) are organized under the top-level elements of the definition (data, collect, manage, evaluate, apply) and are categorized as conceptual competencies, core competencies, and advanced competencies.”



Chantel Ridsdale, et.al.. 2015. Strategies and Best Practices for Data Literacy Education. Dalhousie University. https://dalspace.library.dal.ca/bitstream/handle/10222/64578/Strategies%20and%20Best%20Practices%20for%20Data%20Literacy%20Education.pdf?sequence=1&isAllowed=y (Open University)

Defining Data Literacy

Wolff, et.al. 2016. “Data literacy is the ability to ask and answer real-world questions from large and small data sets through an inquiry process, with consideration of ethical use of data.”

“It is based on core practical and creative skills, with the ability to extend knowledge of specialist data handling skills according to goals. These include the abilities to select, clean, analyse, visualise, critique and interpret data, as well as to communicate stories from data and to use data as part of a design process.”

Figure 3. Complexity of skills for differing roles

Annika Wolff, Daniel Gooch, Jose J. Cavero Montaner, Umar Rashid, Gerd Kortuem. 2016. Creating an understanding of data literacy for a data-driven society.
https://openjournals.uwaterloo.ca/index.php/JoCI/article/view/3275

Defining Data Literacy

Data literacy is the “ability to derive meaningful information from data” (Sperry 2018). “To summarize, a data literate individual would, at minimum, be able to understand information extracted from data and summarized into simple statistics, make further calculations using those statistics, and use the statistics to inform decisions. However, this definition is context-dependent...” (Bonikowska, Sanmartin and Frenette, Statistics Canada, 2019)

https://www150.statcan.gc.ca/n1/pub/11-633-x/11-633-x2019003-eng.htm

Defining Data Literacy

"Data literacy" is formally called out as a new core competency as part of a clear commitment to the organization and leadership valuing "information as a strategic asset." Training programs (online and/or in-person; internal and/or external) are available and supported across all required levels of proficiency. (Gartner, 2019, Toolkit)

Assessment Questions	Response
1. I have identified data literacy as a core skill set and can define its business value for my organization in the modern workplace.	0 1 2 3 4
2. I can "speak data" and cite examples of data-driven decisions within my organization.	0 1 2 3 4
3. I understand the business value of data scientists, data engineers and business analysts and the importance of meeting them frequently and productively.	0 1 2 3 4
4. I can identify myself as a specialist (in data management, data science, information governance and my organization's business domains) or generalist (who can translate and work across the specialties within my organization).	0 1 2 3 4
5. I am empowered by my HR department to develop specific skills related to data literacy and can articulate its contribution to my personal development.	0 1 2 3 4
6. I understand how data adds value to business decisions, participate in formally measuring the value of data and analytics investments, and can cite examples of measurable outcomes powered by data and analytics.	0 1 2 3 4
7. I have confidence in our data management professionals to have strong business acumen and their ability to articulate our strategy, business process areas, key metrics and business analytics.	0 1 2 3 4
8. I regularly participate in meetings where we commonly share and discuss data, metrics, analytics and the decisions they support, and processes and outcomes they improve.	0 1 2 3 4
9. In my role I am empowered to innovate with data, design new data-enabled products and processes, and explore new business models, including monetisation (e.g., selling of data).	0 1 2 3 4
10. I can describe how my organization fits within a business ecosystem, naming examples of our partners, customers and providers.	0 1 2 3 4
11. I understand that information is a strategic asset, and can each explain three examples of how it is, or is not, treated or accounted for as such.	0 1 2 3 4
12. I am able to have a conversation with our data & analytics professionals and understand the differences of a data warehouse, data mart, data lake and data hub.	0 1 2 3 4
13. I have a good understanding of data quality, master data management, application data management, information governance/stewardship and metadata management principles, and can explain the basic value of each with examples in terms that matter.	0 1 2 3 4
14. I can name five data sources (either external or internal) that are relevant to our business now but were not prevalent 10 years ago.	0 1 2 3 4
15. I regularly leverage data-discovery capabilities and tools to accelerate exploration, ingestion and management of new data.	0 1 2 3 4
16. I understand modern technologies such as augmented analytics, can explain the difference between predictive and prescriptive analytics, and can give an example of each.	0 1 2 3 4
17. I commonly use data visualisation and storytelling techniques and can confidently stand up and tell a story with data and visualisation.	0 1 2 3 4
18. I can explain the following terms confidently: mean, median, mode and standard deviation.	0 1 2 3 4
19. I understand how natural-language processing (NLP) and natural-language generation (NLG) are applied, and can describe use cases of each technique.	0 1 2 3 4
20. I understand machine learning (ML) and artificial intelligence (AI) capabilities, and can each describe 3 use cases of ML/AI relevant to my organization.	0 1 2 3 4
21. I understand change is required in the modern workplace and how I need to change to embrace the concept of data literacy.	0 1 2 3 4
22. In addition to classroom based training, I am active in helping others learn and develop e.g., through social learning, on the job coaching, mentoring etc.	0 1 2 3 4
23. In addition to classroom based training, my colleagues are active in helping me and others learn and develop e.g., through social learning, on the job coaching, mentoring etc.	0 1 2 3 4
24. I feel I actively promote and encourage social learning, on the job coaching and mentoring within my organization.	0 1 2 3 4
25. I am given freedom to be experimental in my ways of working and empowered to learn from mistakes.	0 1 2 3 4

Gartner. 2019. Toolkit: Data Literacy Individual Assessment. Gartner. https://www.gartner.com/en/documents/3983897/toolkit-data-literacy-individual-assessment

Alan D. Duncan, Donna Medeiros, Aron Clarke, Sally Parker. 2021. How to Measure the Value of Data Literacy. Gartner. https://www.gartner.com/en/documents/4003941-how-to-measure-the-value-of-data-literacy

Defining Data Literacy

Literacy broadly means having competency in a particular area. Data literacy includes the skills necessary to discover and access data, manipulate data, evaluate data quality, conduct analysis using data, interpret results of analyses, and understand the ethics of using data. (Department of National Defence, 2019)

Department of National Defence . 2019. Annex A – Definitions. The Department of National Defence and Canadian Armed Forces Data Strategy. https://www.canada.ca/en/department-national-defence/corporate/reports-publications/data-strategy.html

John Walsh. 2021. Implementing DND/CAF Data Strategy. Canada.ca, Department of National Defence. https://publicsectornetwork.co/wp-content/uploads/2021/09/John-Walsh-PDF.pdf

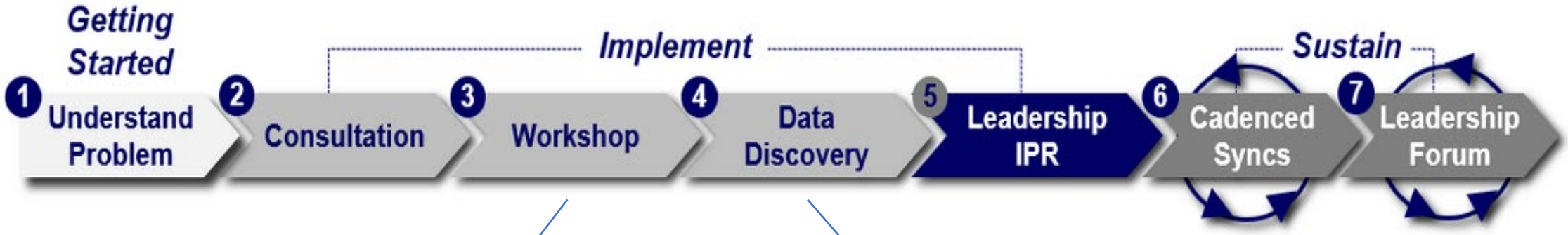
Major Themes

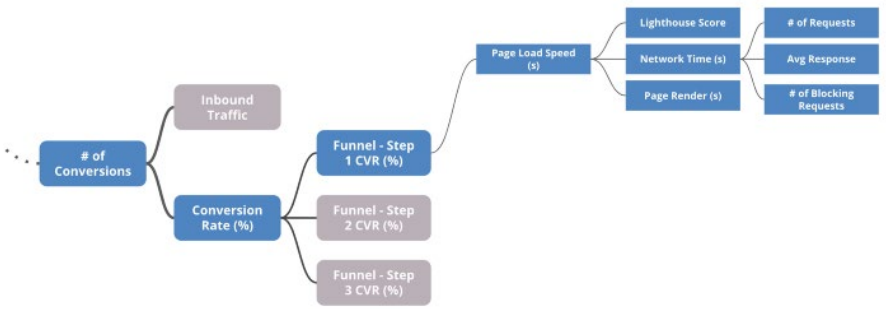
- Data literacy as a set of skills or competencies
- The idea of deriving meaningful information from data
- The data lifecycle or data workflow
- Complexity of skills for differing roles
- Data literacy as individual and corporate capacities

Exmples…

- U.S. Navy – Performance to Plan (P2P)

Drive Navy performance improvement through mission-driven metric reporting advanced data analytics techniques





Driver Tree

Tier	Metric Name	Definition	Data Owner	Data Source	Data Status	Correlation
1	Schedule Adherence	Percentage of CNO avails completing on-time. On-time is defined as completing the availability within the duration stated in the A-30 Ready to Start (RTS) letter or Rebaseline.	CNRMC	Navy Data Environment	Substaintial	N/A
2	Workload Demand vs Past Performance	CNO Maintenance daily workload during execution / CNO Maintenance daily workload 3-9 months prior. (NOTE: Measured quarterly as a rollup of all ships: Metric analyssis provided by CNA.)	CNRMC	Navy Data Environment	Substaintial	Significant

Data Dictionary

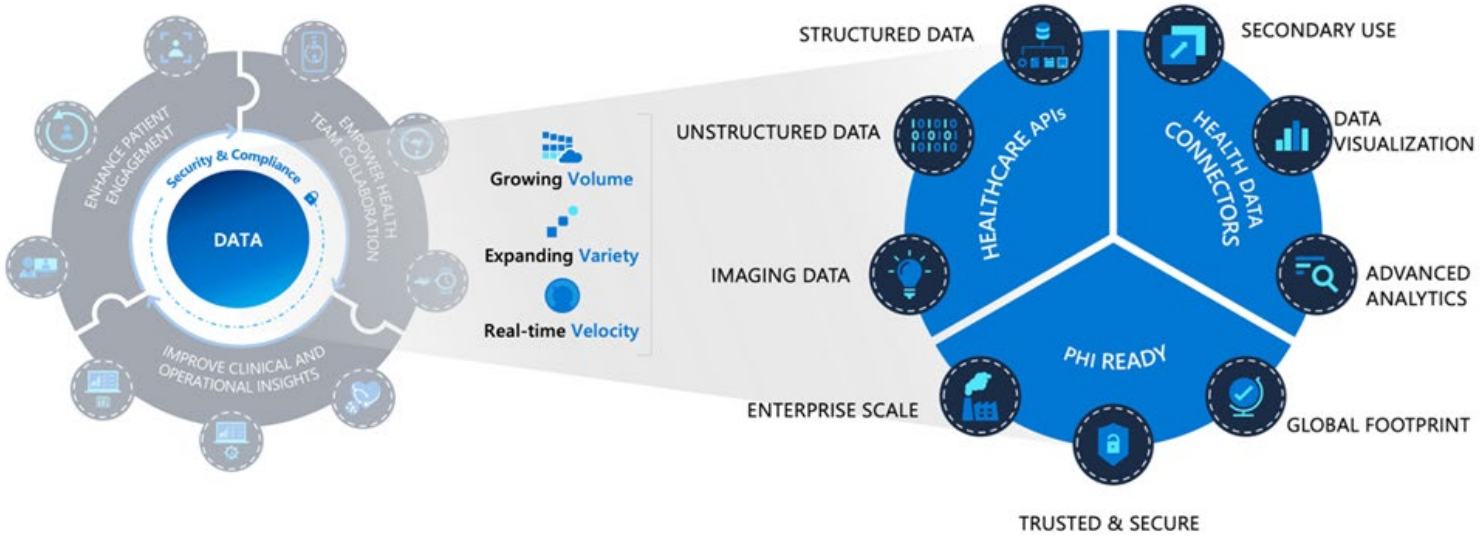
https://p2p.navy.mil/

https://medium.com/swlh/driver-trees-a-tool-to-make-your-teams-more-successful-88f751e86482

Examples

Azure Health Data Services

Example of data management and use (in health care). "Azure Health Data Services, a platform as a service (PaaS) designed to support Protected Health Information (PHI) in the cloud."



Heather Jordan Cartwright. 2022. Microsoft launches Azure Health Data Services to unify health data and power AI in the cloud. Microsoft. https://azure.microsoft.com/en-us/blog/microsoft-launches-azure-health-data-services-to-unify-health-data-and-power-ai-in-the-cloud/

Examples

Datawise

Program to teach instructors to use data to support learning and assessment

Addresses “a need to bridge the resources of an institution of higher education with the instructional capacity of professional development providers and the authentic experiences of school-based practitioners.”

Candice Bocala, Kathryn Parker Boudett, Teaching Educators Habits of Mind for Using Data Wisely, Teachers College Record. https://www.tcrecord.org/Content.asp?ContentID=17853

Boudett, K. P., City, E. A., & Murnane, R. J. (2013). *Data Wise: A step-by-step guide to using assessment results to improve learning and teaching* (revised and expanded ed.). Cambridge, MA: Harvard Education Press.

Data

- “The representation of facts as text, numbers, graphics, images, sound, or video” (The Department of National Defence and Canadian Armed Forces Data Strategy, 2019)

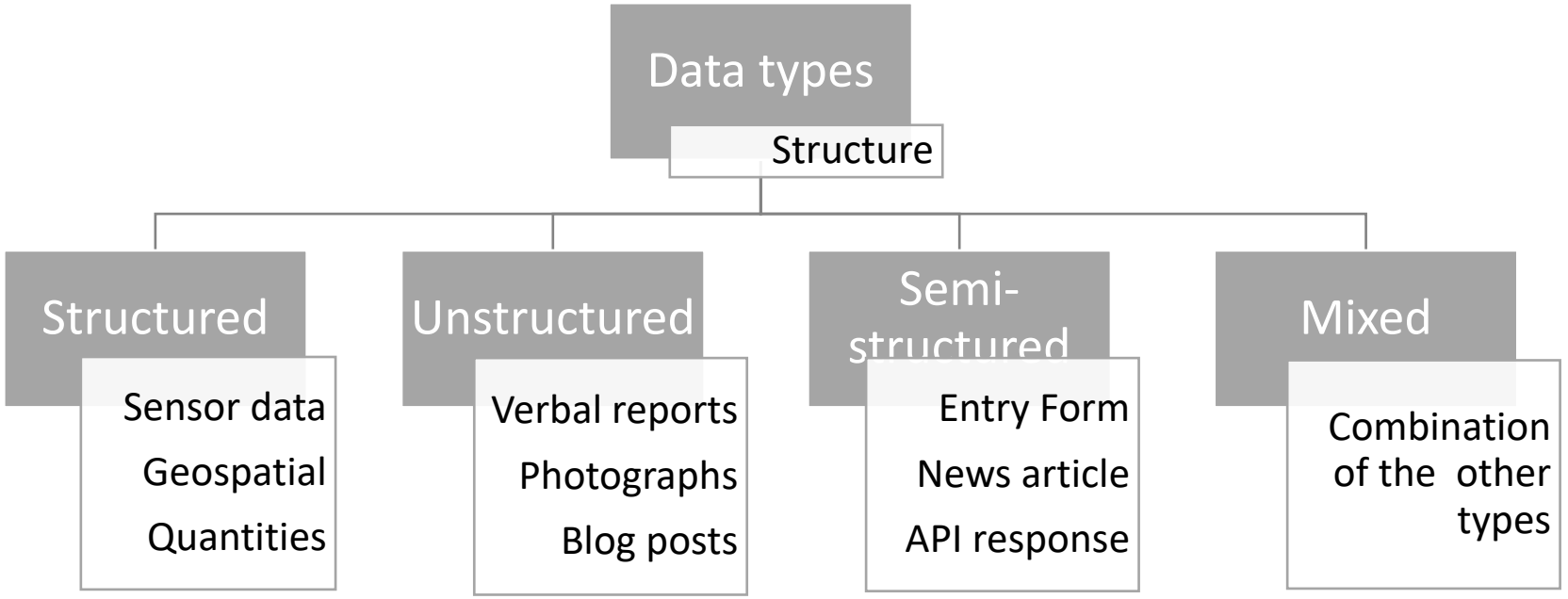
  https://www.canada.ca/en/department-national-defence/corporate/reports-publications/data-strategy.html

- “An object, variable, or piece of information that has the perceived capacity to be collected, stored, and identifiable.” (Bhargava, et.al., 2015)

  https://datapopalliance.org/item/beyond-data-literacy-reinventing-community-engagement-and-empowerment-in-the-age-of-data/

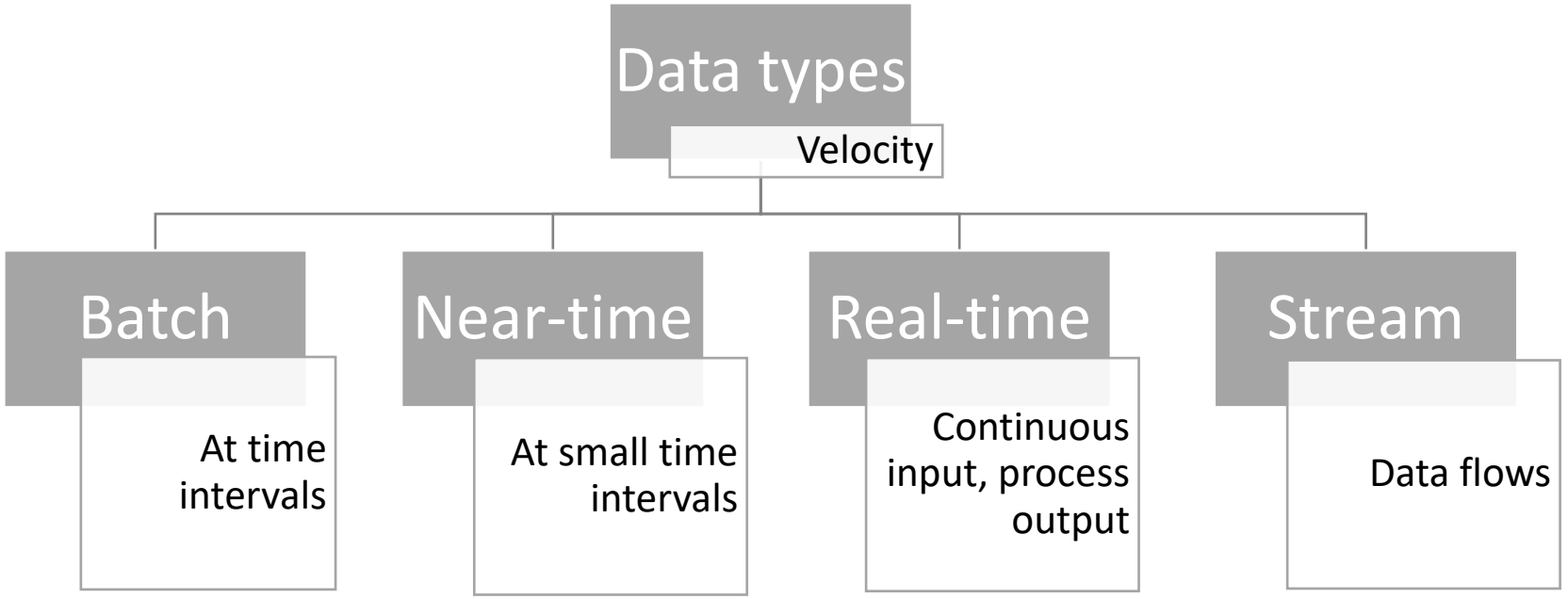
Data

- Types of data



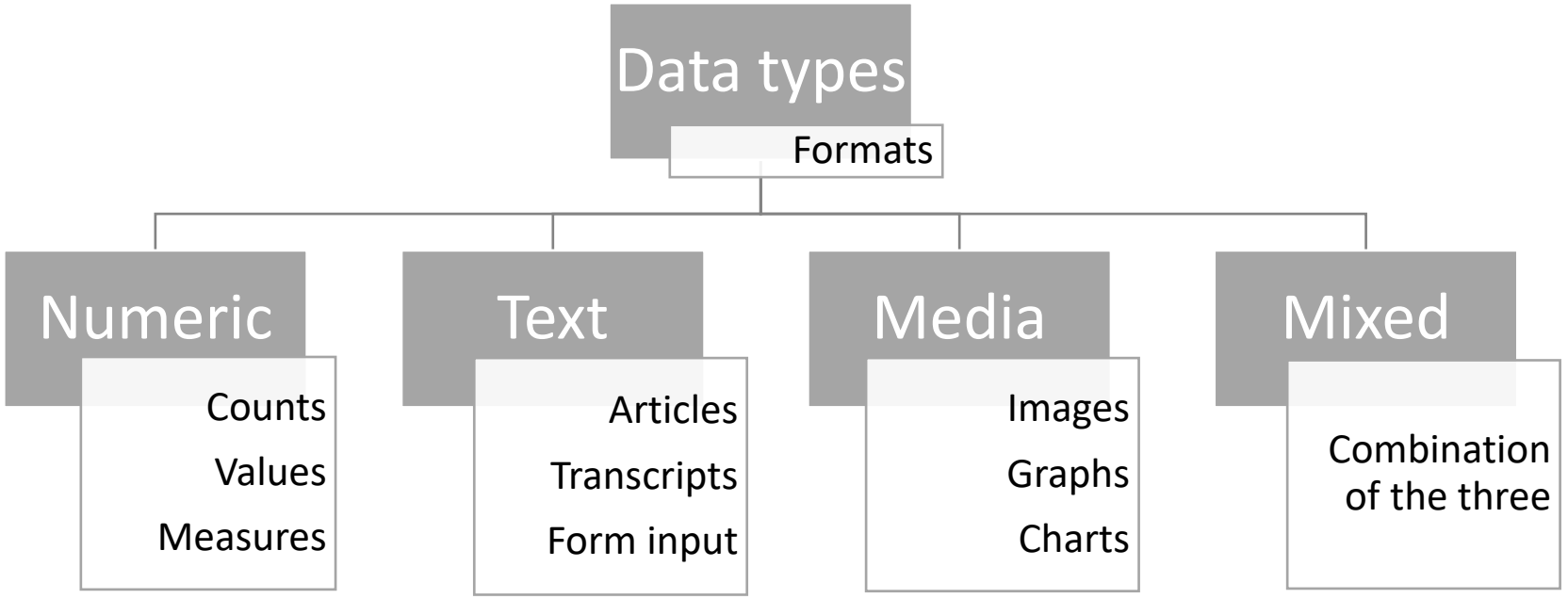
Data

- Types of data



Data

- Types of data



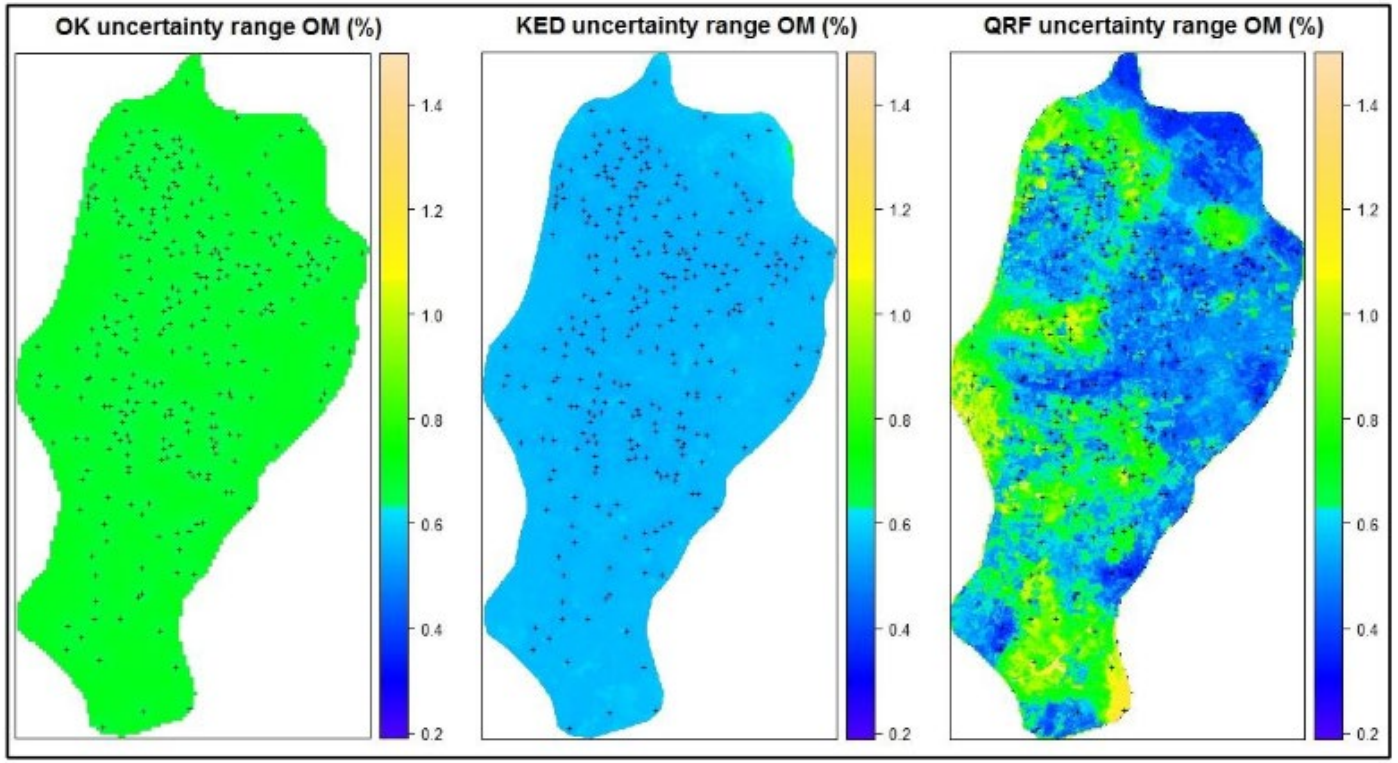
https://datatracker.ietf.org/doc/html/rfc6838
https://guides.library.oregonstate.edu/research-data-services/data-management-types-formats

Data Model

The term ‘machine learning’ was coined in 1959 to describe the application of statistical algorithms to learning problems, for example, how to play checkers.

https://mdpi-res.com/d_attachment/ijgi/ijgi-11-00130/article_deploy/ijgi-11-00130-v2.pdf

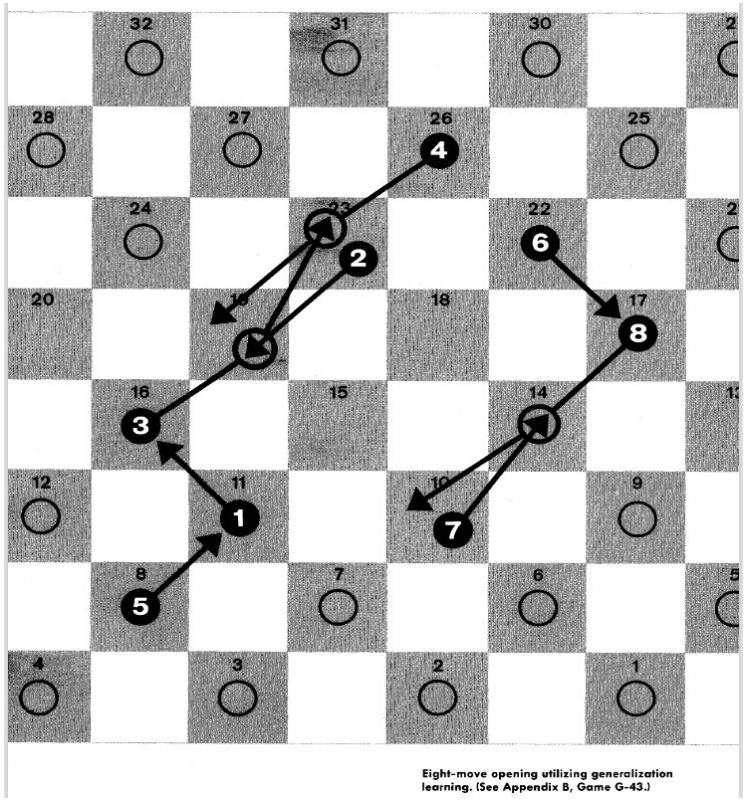
Melpomeni Nikou and Panagiotis Tziachris, 2022



Machine Learning

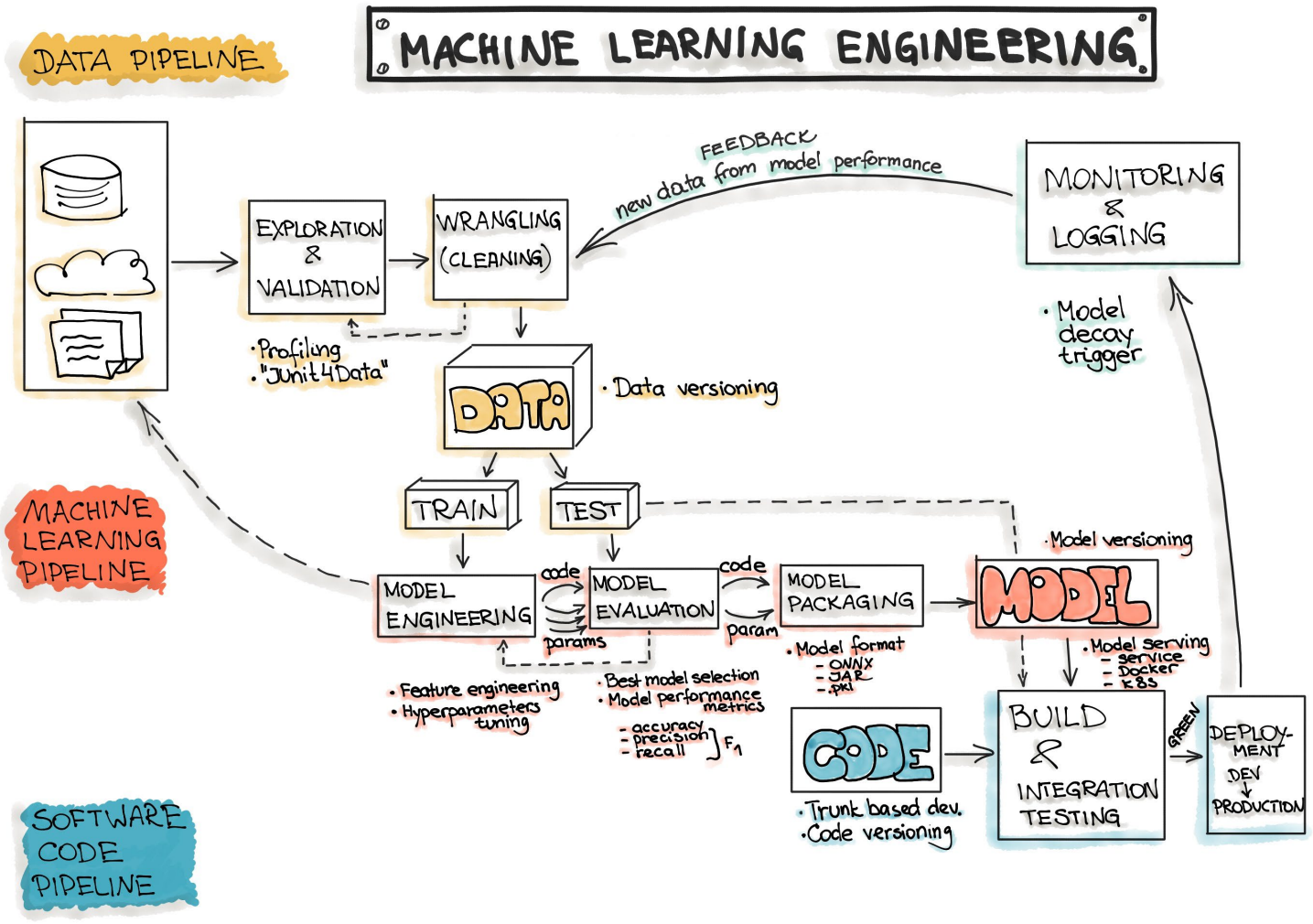
The term ‘machine learning’ was coined in 1959 to describe the application of statistical algorithms to learning problems, for example, how to play checkers.

https://ieeexplore.ieee.org/document/5392560
Arthur Samuel (1959) for IBM



Data Workflows

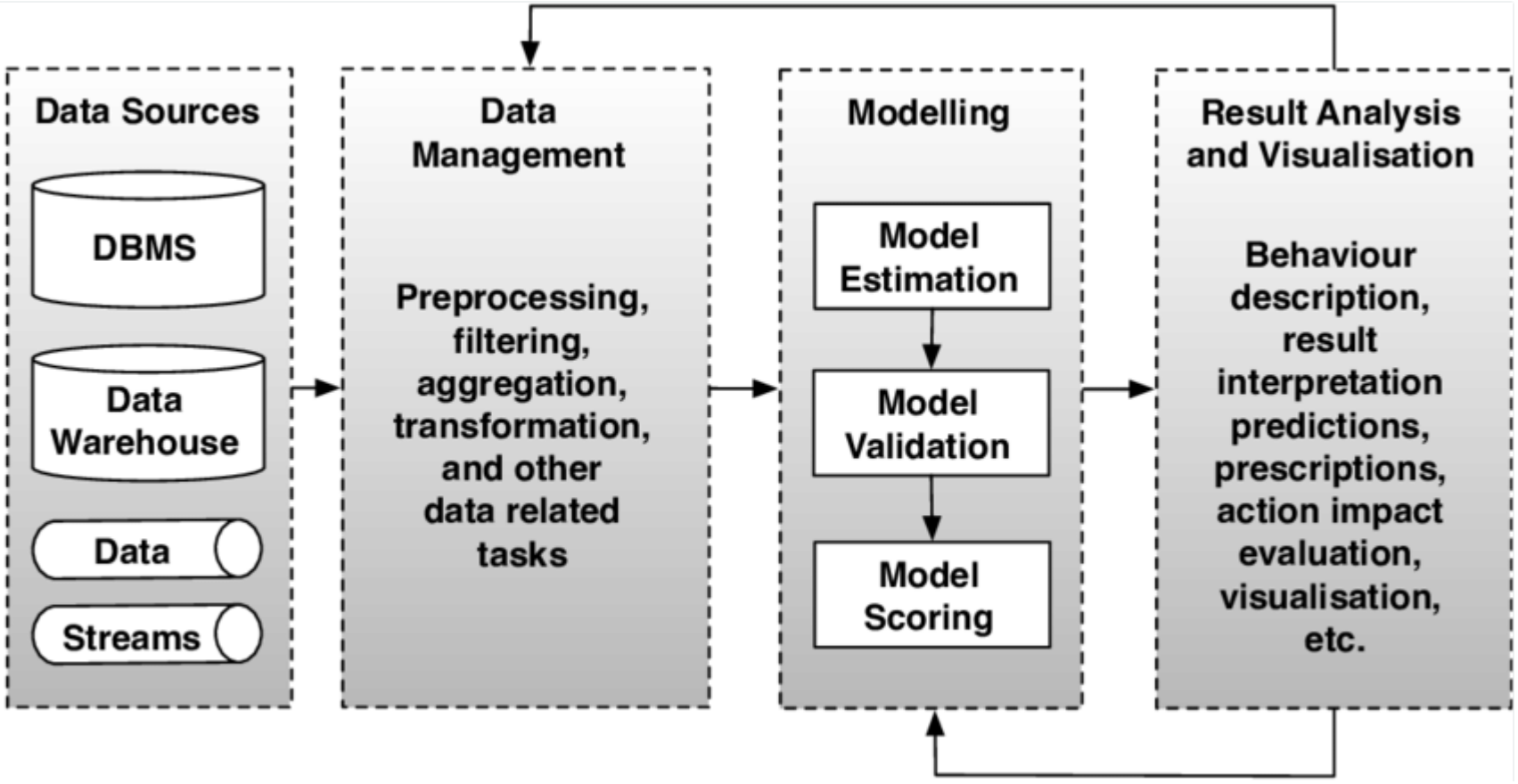
Machine Learning Engineering



MLops https://ml-ops.org/content/end-to-end-ml-workflow

Data Workflows

Big Data Analytics



Marcos D. Assuncao, Rodrigo N. Calheiros, Silvia Bianchi, Marco A. S. Netto, Rajkumar Buyya. (2014). Big Data Computing and Clouds: Trends and Future Directions. Journal of Parallel and Distributed Computing. https://www.researchgate.net/publication/259335041_Big_Data_Computing_and_Clouds_Challenges_Solutions_and_Future_Directions

Data Workflows

GAISE

I. Formulate Statistical Investigative Questions

II. Collect/Consider the Data

III. Analyze the Data

IV. Interpret the Results

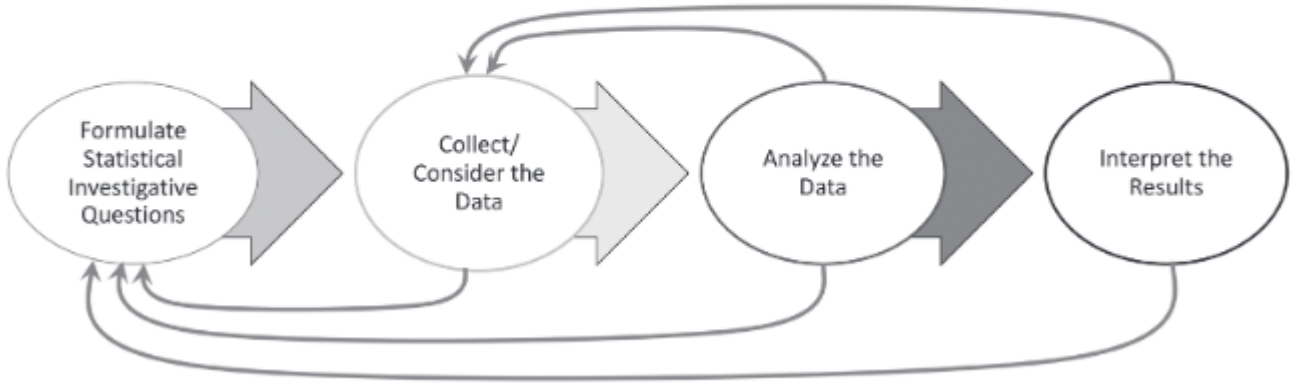


Figure 3: Statistical problem-solving process

Anna Bargagliotti, et.al. (2020). Pre-K–12 Guidelines for Assessment and Instruction in Statistics Education II (GAISE II). American Statistical Association. https://www.amstat.org/docs/default-source/amstat-documents/gaiseiiprek-12_full.pdf

Subdivisions

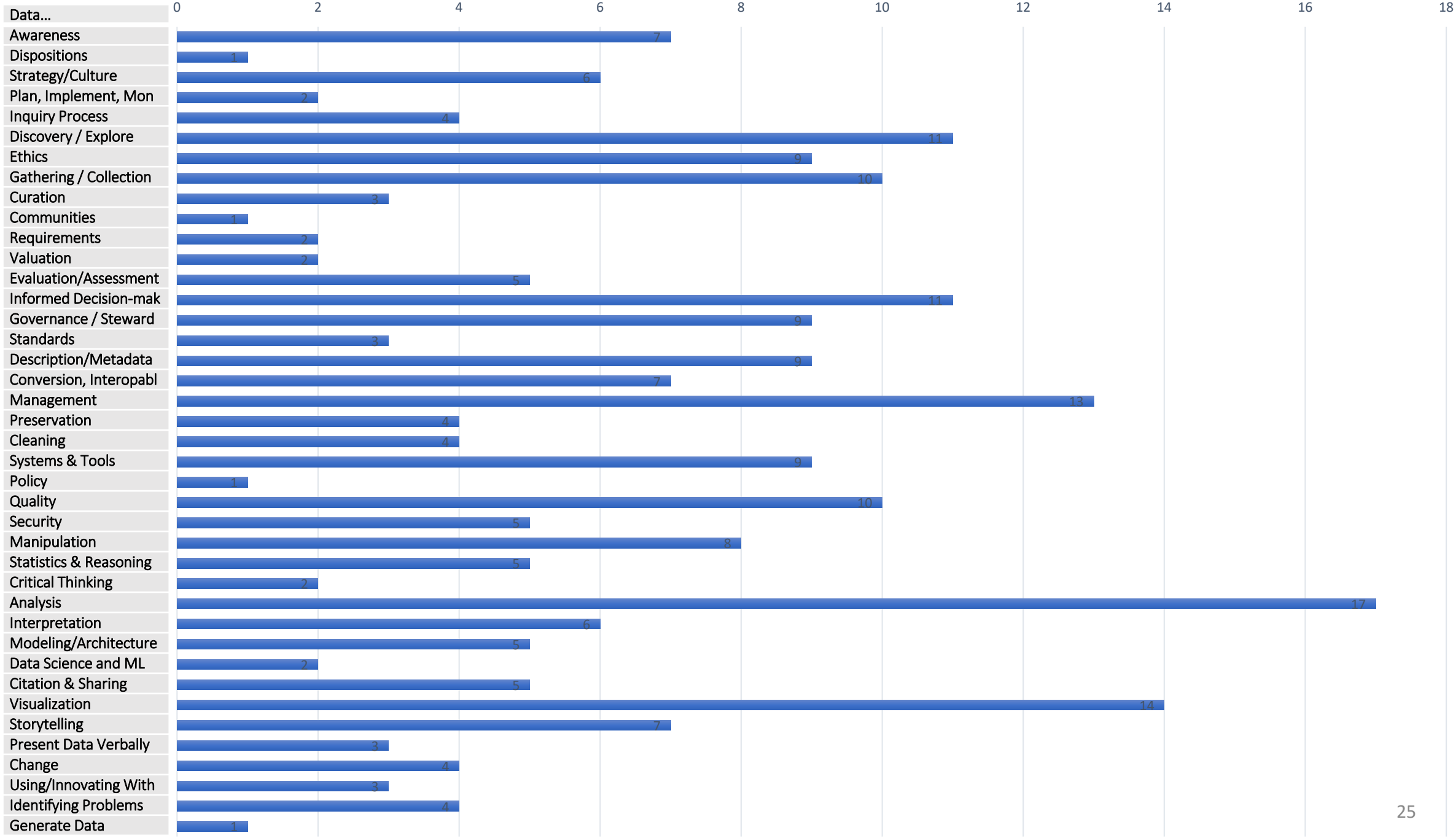
Information Literacy	
Probability and Statistics	
Critical Thinking	
Data Management	

Competencies

- are a set of basic knowledge, skills, abilities, and other characteristics that enable people at work to efficiently and successfully accomplish their job tasks

https://www.sciencedirect.com/science/article/pii/S0360131519303057?casa_token=u0BT0lHseNwAAAAA:AmTC_kv0KFakderwurRBSHFsLt19ApTPqNQ0kmF5hRBxm5QoPIh3oa85ooay1NjGHCWQ_kd7Fw#bib36

Data…	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Awareness	x		x								x			x			x		x	x
Dispositions																				x
Strategy/Culture	x			x		x		x			x				x					
Plan, Implement, Mon														x				x		
Inquiry Process														x			x	x	x	
Discovery / Explore			x		x			x	x		x		x	x	x	x	x			x
Ethics	x		x			x			x	x	x			x	x	x				
Gathering / Collection			x	x					x	x	x		x	x		x		x	x	
Curation										x	x								x	
Communities						x														
Requirements		x							x											
Valuation								x										x		
Evaluation/Assessment					x	x					x						x		x	
Informed Decision-mak	x		x			x	x	x		x	x		x	x			x		x	
Governance / Steward	x	x	x	x		x	x		x									x	x	
Standards	x					x			x											
Description/Metadata						x		x	x	x	x		x				x	x	x	
Conversion, Interopabl	x										x		x		x		x	x	x	
Management		x			x	x	x	x		x	x		x	x		x	x	x	x	
Preservation											x		x			x				x
Cleaning			x			x			x	x										
Systems & Tools	x		x			x					x			x		x	x	x	x	
Policy						x														
Quality	x								x		x	x	x	x	x	x	x	x		
Security	x	x					x			x	x									
Manipulation		x									x		x	x	x	x		x	x	
Statistics & Reasoning								x		x	x							x	x	
Critical Thinking											x					x				
Analysis	x	x	x			x	x	x	x	x	x		x	x	x	x	x	x	x	x
Interpretation											x		x	x	x	x			x	
Modeling/Architecture			x	x			x		x										x	
Data Science and ML							x	x												
Citation & Sharing											x	x				x		x		x
Visualization	x	x	x			x			x		x	x	x		x	x	x	x	x	x
Storytelling	x		x					x	x		x	x							x	
Present Data Verbally											x		x		x					
Change						x	x	x											x	
Using/Innovating With					x	x		x												
Identifying Problems											x		x	x	x					
Generate Data																	x			


Data...
0
2
4
6
8
10
12
14
16
18
Awareness 7
Dispositions 1
Strategy/Culture 6
Plan, Implement, Mon 2
Inquiry Process 4
Discovery / Explore 11
Ethics 9
Gathering / Collection 10
Curation 3
Communities 1
Requirements 2
Valuation 2
Evaluation/Assessment 5
Informed Decision-mak 11
Governance / Steward 9
Standards 3
Description/Metadata 9
Conversion, Interopabl 7
Management 13
Preservation 4
Cleaning 4
Systems & Tools 9
Policy 1
Quality 10
Security 5
Manipulation 8
Statistics & Reasoning 5
Critical Thinking 2
Analysis 17
Interpretation 6
Modeling/Architecture 5
Data Science and ML 2
Citation & Sharing 5
Visualization 14
Storytelling 7
Present Data Verbally 3
Change 4
Using/Innovating With 3
Identifying Problems 4
Generate Data 1

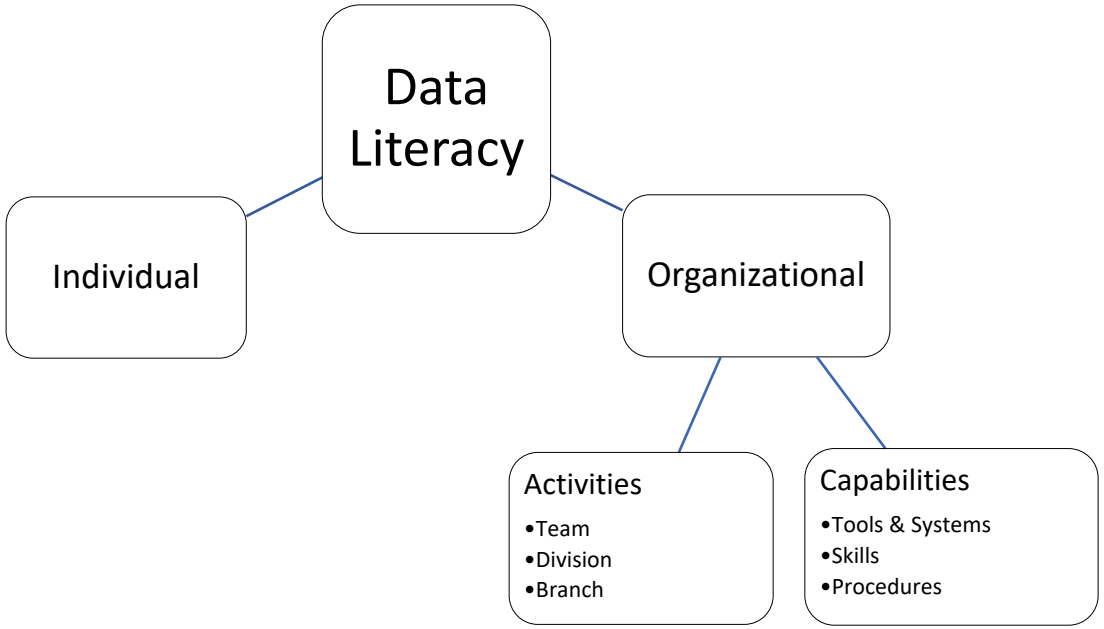
Data…	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Awareness	x		x								x			x			x		x	x
Dispositions																				x
Strategy/Culture	x			x		x		x			x				x					
Plan, Implement, Mon														x				x		
Inquiry Process														x			x	x	x	
Discovery / Explore			x		x			x	x		x		x	x	x	x	x			x
Ethics	x		x			x			x	x	x			x	x	x				
Gathering / Collection			x	x					x	x	x		x	x		x		x	x	
Curation										x	x								x	
Communities						x														
Requirements		x							x											
Valuation								x										x		
Evaluation/Assessment					x	x					x						x		x	
Informed Decision-mak	x		x			x	x	x		x	x		x	x			x		x	
Governance / Steward	x	x	x	x		x	x		x									x	x	
Standards	x					x			x											
Description/Metadata						x		x	x	x	x		x				x	x	x	
Conversion, Interopabl	x										x		x		x		x	x	x	
Management		x			x	x	x	x		x	x		x	x		x	x	x	x	
Preservation											x		x			x				x
Cleaning			x			x			x	x										
Systems & Tools	x		x			x					x			x		x	x	x	x	
Policy						x														
Quality	x								x		x	x	x	x	x	x	x	x		
Security	x	x					x			x	x									
Manipulation		x									x		x	x	x	x		x	x	
Statistics & Reasoning								x		x	x							x	x	
Critical Thinking											x					x				
Analysis	x	x	x			x	x	x	x	x	x		x	x	x	x	x	x	x	x
Interpretation											x		x	x	x	x			x	
Modeling/Architecture			x	x			x		x										x	
Data Science and ML							x	x												
Citation & Sharing											x	x				x		x		x
Visualization	x	x	x			x			x		x	x	x		x	x	x	x	x	x
Storytelling	x		x					x	x		x	x							x	
Present Data Verbally											x		x		x					
Change						x	x	x											x	
Using/Innovating With					x	x		x												
Identifying Problems											x		x	x	x					
Generate Data																	x			

Row 13
Databilities

Defining Data Literacy

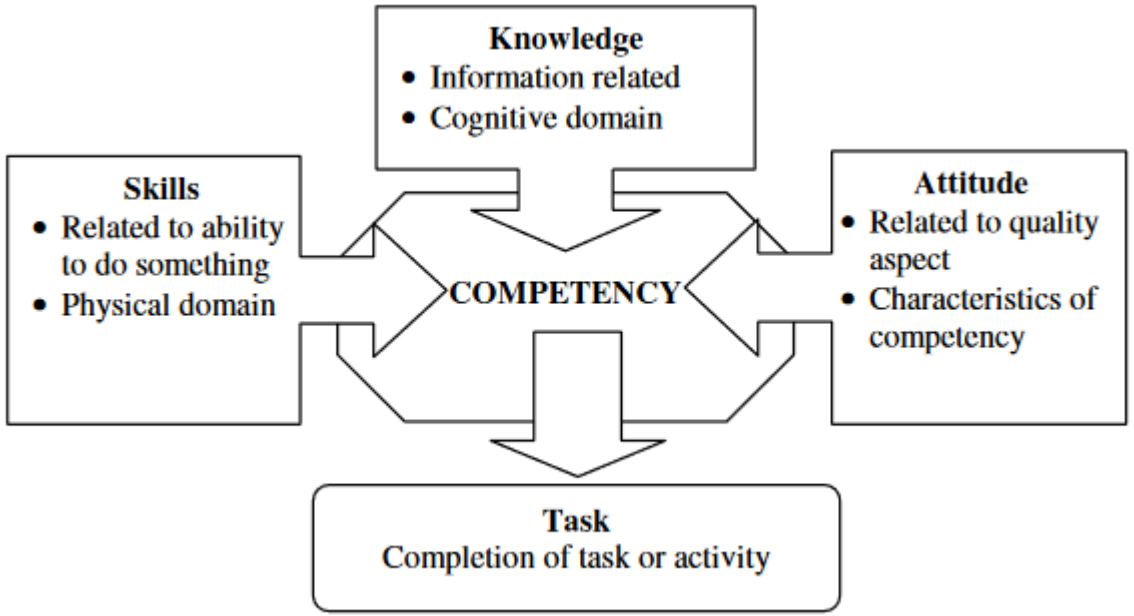
Individual	Organizational		
	Team	Division	Branch
	Tools and systems	Employee skills and capabilities	Procedures and mechanisms

Defining Data Literacy



Competencies

Specifically, “a competency is a set of skills, related knowledge and attributes that allow an individual to successfully perform a task or an activity within a specific function or job” (United Nations Industrial Development Organization (UNIDO), 2002).



https://www.researchgate.net/publication/282971399_Competency_of_Adult_Learners_in_Learning_Application_of_the_Iceberg_Competency_Model

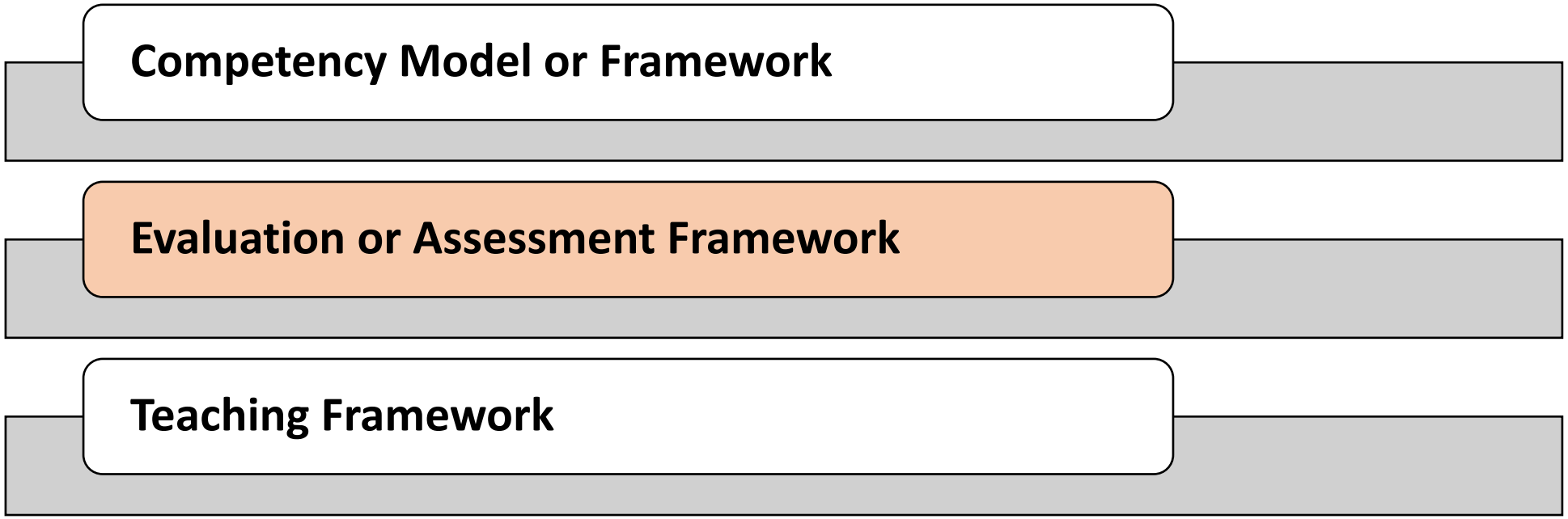
UNIDO competencies: Strengthening organizational core values and managerial capabilities
https://docplayer.net/9459584-Unido-competencies-strengthening-organizational-core-values-and-managerial-capabilities.html

Defining Data Literacy

Individual	Organizational
Knowledge	Definitions
Skills / Competencies	Capacities
Attitudes	Practices

Example: Data Visualization

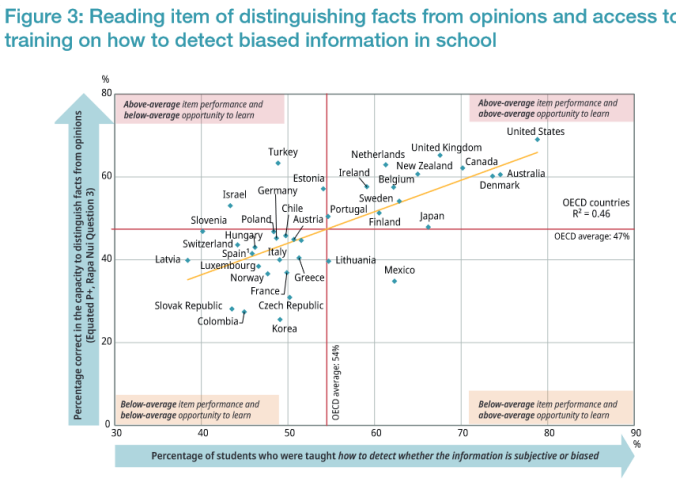
Individual	Organizational
Knowledge - knows visualization formats - understands data representation	Definitions - standard visualizations for key data - visualizations referenced to original data
Skills / Competencies - can create visualizations from data - can generate meaning from visualizations	Capacities - staff have access to data visualizations - staff includes data visualization expertise
Attitudes - is comfortable working with visualizations - recognizes importance of visualizations	Practices - maintains data visualization software tools - data visualization part of reports workflow

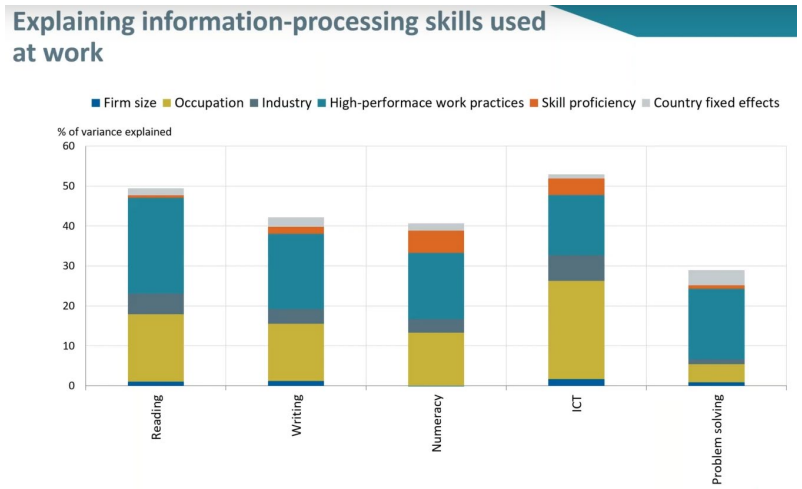

Competency Model or Framework
Evaluation or Assessment Framework
Teaching Framework

Assessment Programs

OECD

- The Programme for the International Assessment of Adult Competencies (PIAAC)
- Programme for International Student Assessment (PISA)





https://www.oecd-ilibrary.org/education/the-policy-impact-of-pisa_5k9fdfqffr28-en

(PIAAC) (Second Edition) (2016) https://www.oecd.org/skills/piaac/PIAAC_Technical_Report_2nd_Edition_Full_Report.pdf

OECD (PISA). 2021. Are 15-year-olds prepared to deal with fake news and misinformation? https://www.oecd-ilibrary.org/education/are-15-year-olds-prepared-to-deal-with-fake-news-and-misinformation_6ad5395e-en

OECD (PIAAC). 2021. PIAAC Round 3 International Launch Webinar. https://www.oecd.org/skills/piaac/

Assessment Programs

Guidelines for Assessment and Instruction in Statistics Education (GAISE)

Robert Carver, et.al.. (2016). Guidelines for Assessment and Instruction in Statistics Education (GAISE) College Report. American Statistical Association. https://www.amstat.org/docs/default-source/amstat-documents/gaisecollege_full.pdf

Anna Bargagliotti, et.al. (2020). Pre-K–12 Guidelines for Assessment and Instruction in Statistics Education II (GAISE II). American Statistical Association. https://www.amstat.org/docs/default-source/amstat-documents/gaiseiiprek-12_full.pdf

https://journals.gmu.edu/index.php/ITLCP/article/view/2241

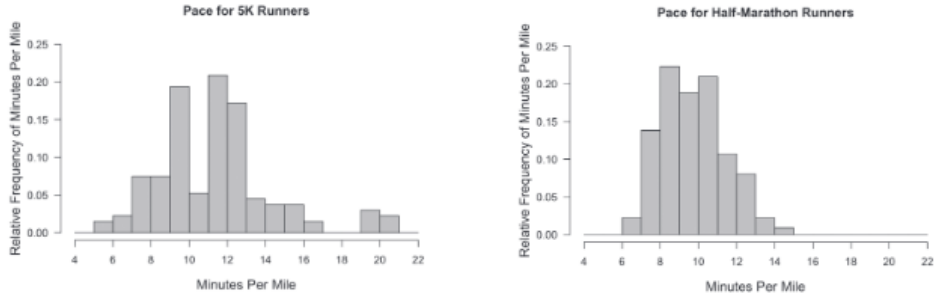


Figure 3: Histograms for runners

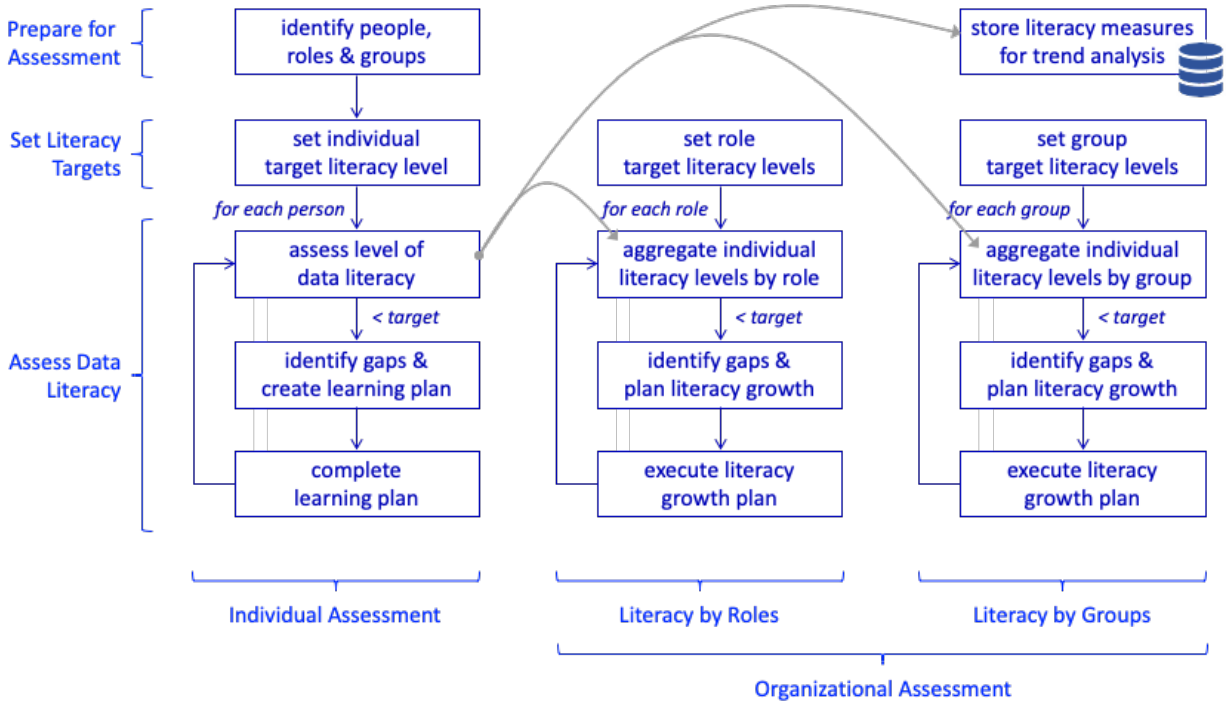
(a) Jaron predicted that the mile times of runners in the 5K race would be more consistent than the mile times of runners in the half-marathon. Do these data support Jaron's statement? Explain why or why not.

(b) Sierra predicted that, on average, the mile time for runners of the half-marathon would be greater than the mile time for runners of the 5K race. Do these data support Sierra's statement? Explain why or why not.

(c) Recall that individual runners chose to run only one of the two races. Based on these data, is it reasonable to conclude that the mile time of a person would be less when that person runs a half-marathon than when he or she runs a 5K? Explain why or why not.

Assessment Programs

Eckerson Group Data Literacy Imperative

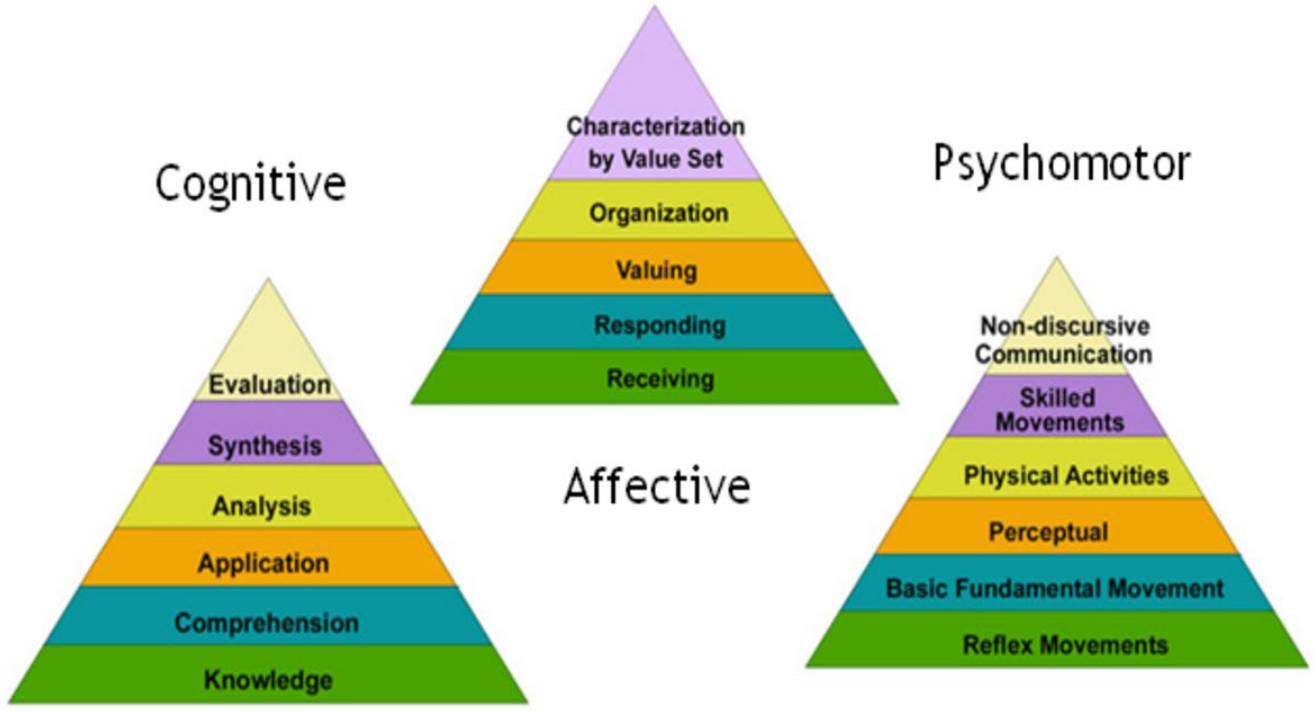


https://ecm.elearningcurve.com/Articles.asp?ID=369

Dave Wells. 2022. The Data Literacy Imperative - Part III: Data Literacy Assessment. Eckerson Group. https://www.eckerson.com/articles/the-data-literacy-imperative-part-iii-data-literacy-assessment

Data Literacy Model-Based Assessment

- Extant list of skills based on empirical analysis of data workflows
- This list can be cross-referenced with a comprehensive skills taxonomy
  - (For simplicity I used a modified Bloom's Taxonomy)
  - Treated as *taxonomies* not hierarchies
  - Represented as types of skills or competences



https://psycnet.apa.org/record/2003-00041-000

Assessing Data Literacy

Bloom's	Individual	Organizational
Cognitive	Knowledge	Definitions
Psychomotor	Skills / Competencies	Capacities
Affective	Attitudes	Practices

Knowledge

Individual	Organizational
Knowledge - Know what data is, recognize data vs non-data	- Has or uses data in some way
Comprehension - Know methods to read data, comprehend data	- Provides mechanisms for data access
Application - Know how data can be used	- Data can be used as input in tools and systems
Analysis - Understand parts of data, types of data	- Data can be accessed in different views, formats
Synthesis - Know ways to join of connect data	- Data can be pooled or connected
Evaluation - Identify quality data, appropriate data	- The are organizational data quality standards
Creation - Create data	- Data is recorded and produced in the organization

Skills / Competencies

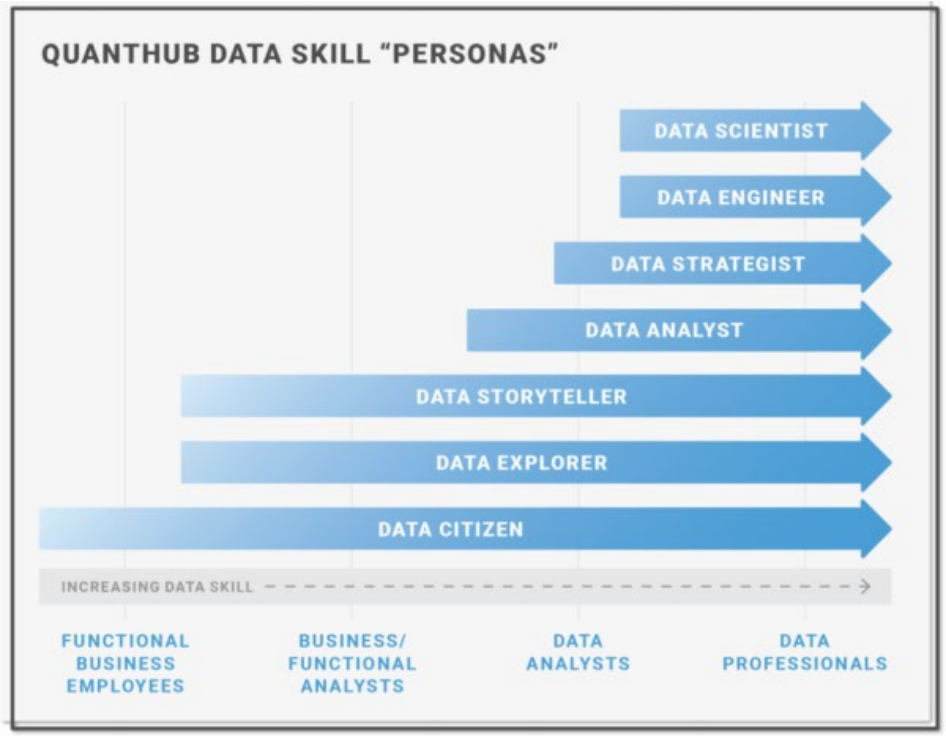
Individual	Organizational
Perception - Be able to discover, read, explore data	- The organization actively collects data
Set - Can follow data processes and procedures	- There are data management processes
Guided Response - Can follow instructions and respond to data	- There is a capacity to respond to data
Mechanism - Knows about and can use data tools and systems	- Data management tools and systems are supported
Complex Overt Response - Can make decisions using data	- Decisions are driven by data
Adaptation - Can create data visualizations, stories	- Visualizations and data stories are used
Origination - Can create and share data from new sources	- The organization regularly collects and shares data

Attitudes

Individual	Organizational
Receiving - Is open to learning from data	- Data is welcomed and sought after
Recognizing - Can detect patterns and regularities in data	- Data is considered and analyzed; there are data-based alerts
Responding - Is willing to act on new data	- Data drives actions and responses to challenges
Framing - Is willing to work in a data-centered way	- Knowledge management is data centered
Valuing - Values and can assign value to different types of data	- Data is valued in the organization and quality controls apply
Organizing - Actively orients data to address challenges	- Key strategies are oriented by data
Characterizing - Develops abstractions, generalizations and principles	- Organizational frameworks, structures, procedures driven by data

Levels

- GAISE: Levels A, B, C program contents
- Quanthub Personas



Jen DuBois. 2022. Thriving Data Culture Starts with Data Literacy Assessments. QuantHub. https://quanthub.com/data-literacy-assessment/

NU Data, a professional development intervention aimed at preparing special education teams to use data-based decision making to improve academic outcomes for students with disabilities. Doll, et.al., 2014.
https://ies.ed.gov/funding/grantsearch/details.asp?ID=1131
Sikorski, 2016
https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1268&context=cehsdiss

Means, et.al. 2011. Teachers' Ability to Use Data to Inform Instruction: Challenges and Supports
Below Basic, Basic, Proficient, Advanced
https://www2.ed.gov/rschstat/eval/data-to-inform-instruction/report.pdf

https://dataliteracy.com/data-literacy-score/

Role-Defined Data Literacy

Knowledge
- Know what data is, recognize data vs non-data

Comprehension
- Know methods to read data, comprehend data

Application
- Know how data can be used

Analysis
- Understand parts of data, types of data

Synthesis
- Know ways to join of connect data

Evaluation
- Identify quality data, appropriate data

Perception
- Be able to discover, read, explore data

Set
- Can follow data processes and procedures

Guided Response
- Can follow instructions and respond to data

Mechanism
- Knows about and can use data tools and systems

Complex Overt Response
- Can make decisions using data

Adaptation
- Can create data visualizations, stories

Origination
- Can create and share data from new sources

Etc…

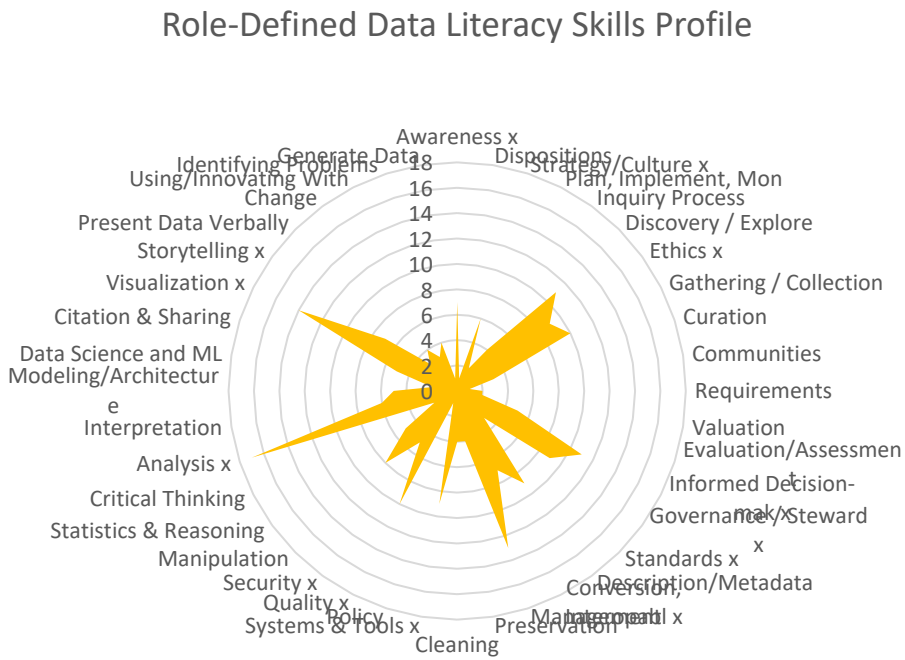
OVERVIEW

Information Systems Technicians are experts in Information Technologies (IT) who deploy, establish, administer, and maintain multi-platform networking computer environments, and a variety of data and voice networks. They are a part of a larger team that provides the Canadian Armed Forces (CAF) with communications and information services throughout Canada and around the world. They handle communications and information systems equipment, such as:

- Wired and wireless communications and information systems
- Fibre optic and copper wire broadband technology
- Voice and data network equipment and servers

WORK ENVIRONMENT

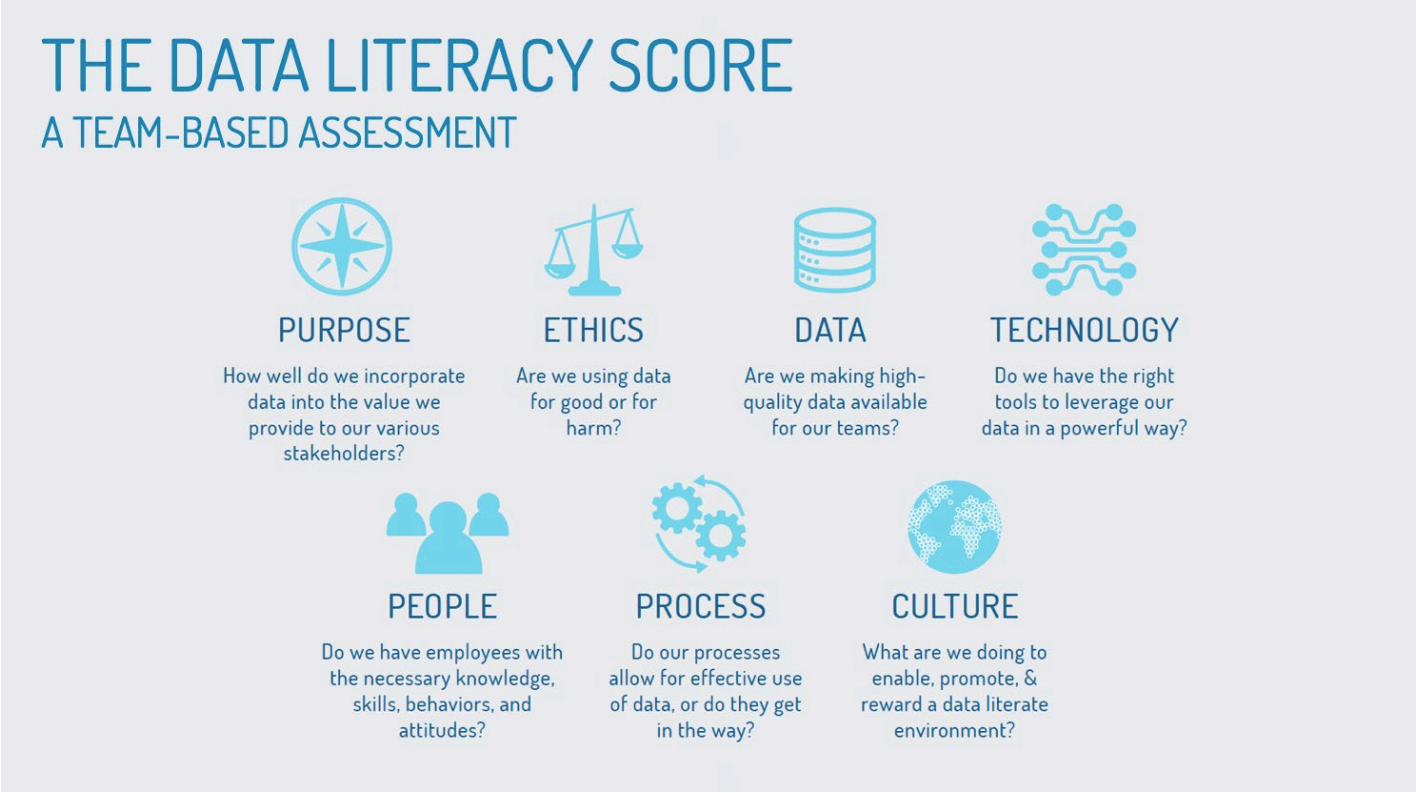
Information Systems Technicians experience the unique adventures and challenges that come with working outdoors, in military vehicles and server rooms. Information Systems Technicians work across the country and around the world wherever the CAF has a footprint.



https://forces.ca/en/careers

Assessment Methods

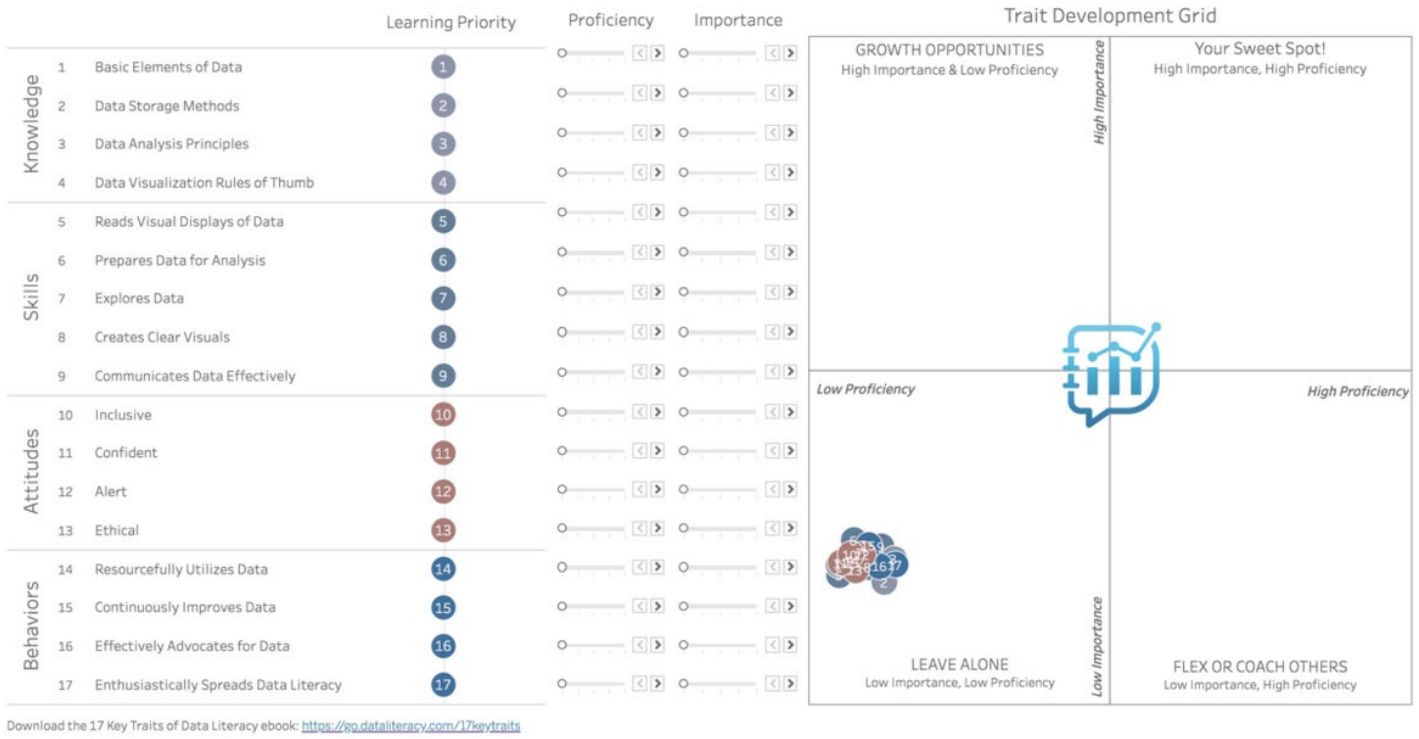
- Self-Report
- Skills Test (Multiple Choice)
- Skills Test (Open Response)
- Analysis



https://dataliteracy.com/data-literacy-score/

Methods

Self-Report

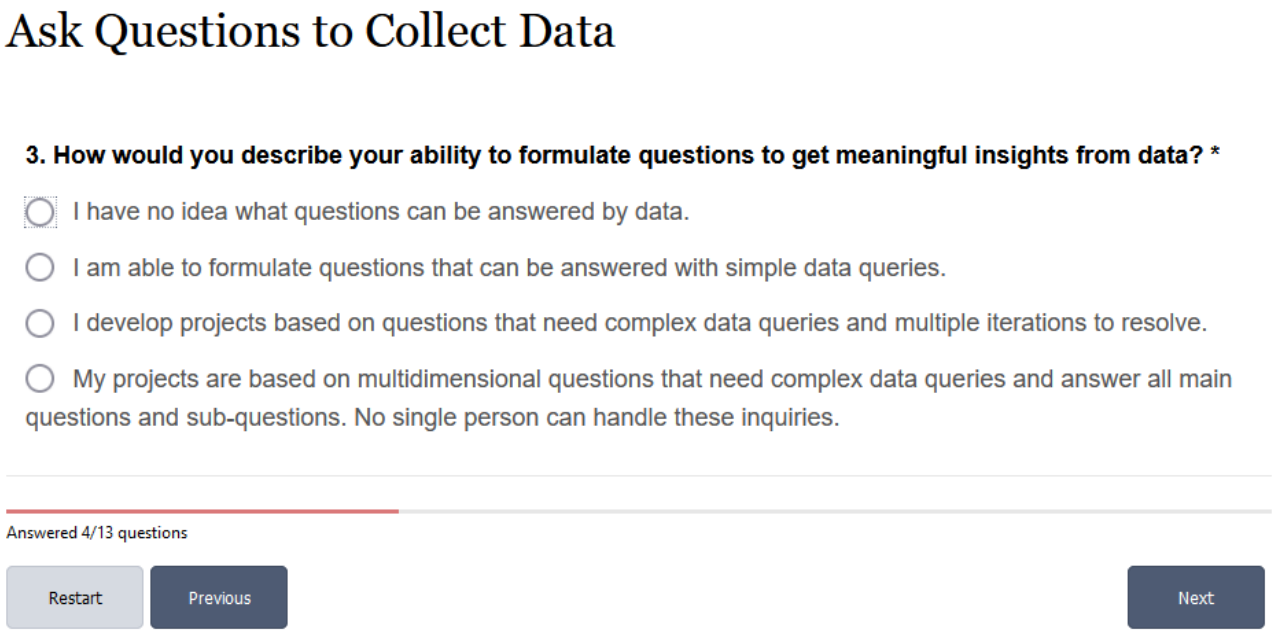


2019. Take the 17 Key Traits of Data Literacy Self-Assessment. Data Literacy. https://dataliteracy.com/take-the-17-key-traits-self-assessment/

Ben Jones. 2021. A Data Literacy Assessment for Every Employee. Udemy. https://business.udemy.com/resources/data-skills-assessment-template/

Methods

Self-Report



Fix, 2022. The Dunning-Kruger Effect is Autocorrelation https://economicsfromthetopdown.com/2022/04/08/the-dunning-kruger-effect-is-autocorrelation/

Canada School of Public Service. . How Data Literate Are You?. Government of Canada. https://catalogue.csps-efpc.gc.ca/product?catalog=DDN302&cm_locale=en

Criticism: Williams, et.al., 2017 https://psych.utah.edu/_resources/documents/people/williams/williams-et-al_pa-17.pdf

Method

Skills Test (Open Response)

Task:	Write a **news report** based on the headline and picture below. • You will have to make up the facts and information to answer some or all of the following questions: Who? What? Where? When? Why? How? • You must relate your newspaper report to **both** the headline **and** the picture.
Purpose & Audience:	to report on an event for the readers of a newspaper
Length:	The lined space provided in the *Answer Booklet* for your written work indicates the approximate length of the writing expected.

https://www.ugdsb.ca/jfr/literacy-test-osslt-ross/
https://drive.google.com/file/d/1LsDbvAy_YHepMVD9VVEEWH6w5U_Dk1-E/view

Fostering Data Literacy through Preservice Teacher Inquiry in English Language Arts
https://education.ucdavis.edu/sites/main/files/file-attachments/teacher_inquiry_and_data_literacy.pdf

Method

Rubric

Indicator	4 Exceeds expectations	3 Meets expectations	2 Needs improvement	1 Inadequate
Describing data: Ability to say what patterns or relationships are seen between data points.	Meets expectations and one or more of the following: Comparison references specific data values beyond the scope of what is asked (e.g., magnitude and/or statistical comparisons). Creatively presents data visualization or uses more advanced tools to show data relationship. Appropriately uses scientific vocabulary to describe patterns.	Description of the data pattern is accurate. Makes quantitative comparison that refers to specific data values. Makes a comparison or describes a pattern that is relevant to the scientific question. Data visualization is properly annotated with descriptions or comparisons, per instructions. *A solely qualitative comparison can be scored a 3 only if the scoring guide explicitly notes that a quantitative description is not possible.*	Description of the data pattern is attempted, but inaccurate. Makes no quantitative comparison or reference to data values. Makes a qualitative comparison of a pattern relevant to the scientific question. Data visualization is minimally annotated OR annotations are incomplete or incorrect.	Provides little or no description of data patterns. Makes a qualitative comparison, but it is irrelevant to the scientific question. Provides a description that is a summary of background information without use of OT data. Does not include a data visualization OR a visualization with no annotation.

Levels of proficiency for describing data, excerpted from full rubric. https://www.nsta.org/journal-college-science-teaching/journal-college-science-teaching-marchapril-2021/measuring-data

AI essay graders https://www.frontiersin.org/articles/10.3389/feduc.2020.572367/full

Method

Skills Test (Multiple Choice)

The objective here is to develop a multiple-choice ("MC") assessment of students' ability that compares favorably with more time-consuming, open response instruments.

Design and development effort using Rasch modeling. "The Rasch model assumes that the underlying construct that is being measured varies along a single dimension (Bond & Fox, 2012)."

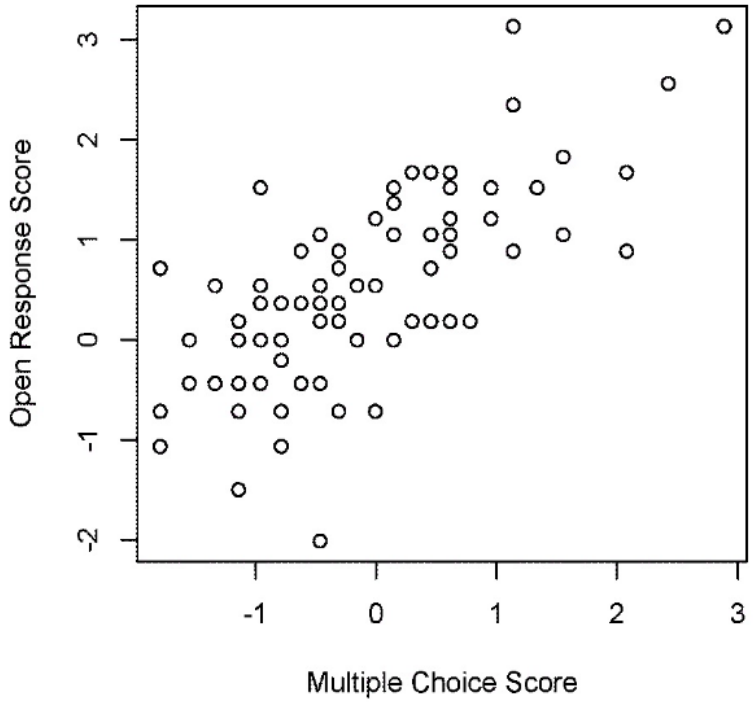


Figure 2. Relationship of MC and OR scores

Bill Zoellick, Molly Schauffler, Marcella Flubacher. Ryan Weatherbee, Hannah Webber. (2016). Data Literacy: Assessing Student Understanding of Variability in Data. Annual Meeting of the National Association for Research in Science Teaching. https://www.researchgate.net/publication/301802243_Data_Literacy_Assessing_Student_Understanding_of_Variability_in_Data

What does it mean that MacAlpine's experiments "have shown promise" (paragraph 5)?

Click your answer choice.

- MacAlpine has almost completed her research.
- MacAlpine's intentions were questioned by scientists.
- MacAlpine's investigations have the potential to be successful.
- MacAlpine's compound is ready to become a commercial drug.

https://www.eqao.com/the-assessments/osslt/

Method

Analysis

E.g. Data literacy was measured on the 60 students using a written essay test of 6 items, according to the aspects contained in data literacy

Term	Definition
Immersion in the data	The process of becoming intimately familiar with the content being analyzed, through transcription, repeated reading, and/or several iterations of coding
Unit of meaning	Several words, a sentence, or a statement that represents a single idea or concept
Condensation	The process of shortening a unit of meaning while retaining the original meaning
Code	A short (typically 1-3 words) label that describes a unit of meaning/condensed unit of meaning
Category	An organization of several codes that are related in either content or context. In the case of a large number of codes, sub-categories may serve as a useful intermediate grouping
Theme	An organization of two or more categories that represent an underlying meaning. Themes describe behaviors, experiences, or emotions that occur throughout several categories

https://scholarspace.manoa.hawaii.edu/bitstream/10125/44616/1/21_02_golonkatarebonilla.pdf
https://dl.acm.org/doi/abs/10.1145/3462741.3466663?casa_token=02Ul1Mcs-kYAAAAA:7s1DZW-orZqgEf48pi9bOqSJb0sLsQ8IGoaRdLC93JsyGL1DGszfi06q8lG6MFcdlClb3q2x_NeuYg

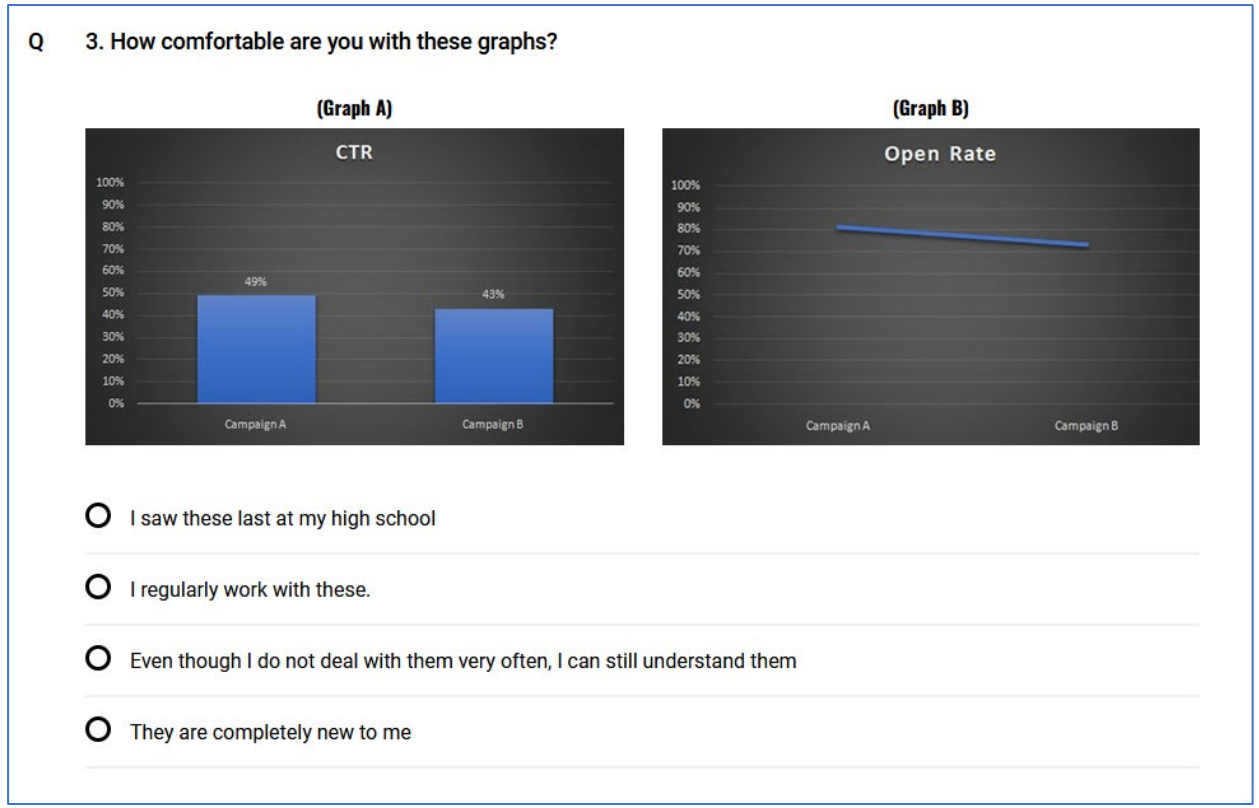
Suryadi, I K Mahardika, Supeno, Sudarti. (2021). Data literacy of high school students on physics learning. Journal of Physics: Conference Series. https://www.researchgate.net/publication/350169382_Data_literacy_of_high_school_students_on_physics_learning

A. J. Kleinheksel, Nicole Rockich-Winston, Huda Tawfik, Tasha R. Wyatt. (2020). Demystifying Content Analysis. American Journal of Pharmaceutical Education. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7055418/

Method

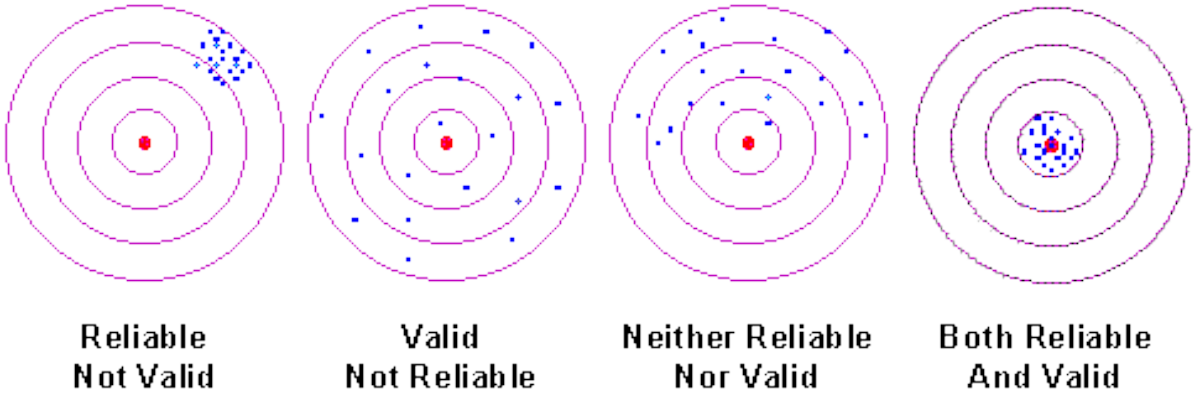
Mixed

Example:
Short 10-question quiz with a mix of attitude questions and objective questions to classify people into one of six 'data literacy' categories.



2022. Data literacy assessment. Aryng. https://aryng.com/data-literacy-test

Reliability and Validity



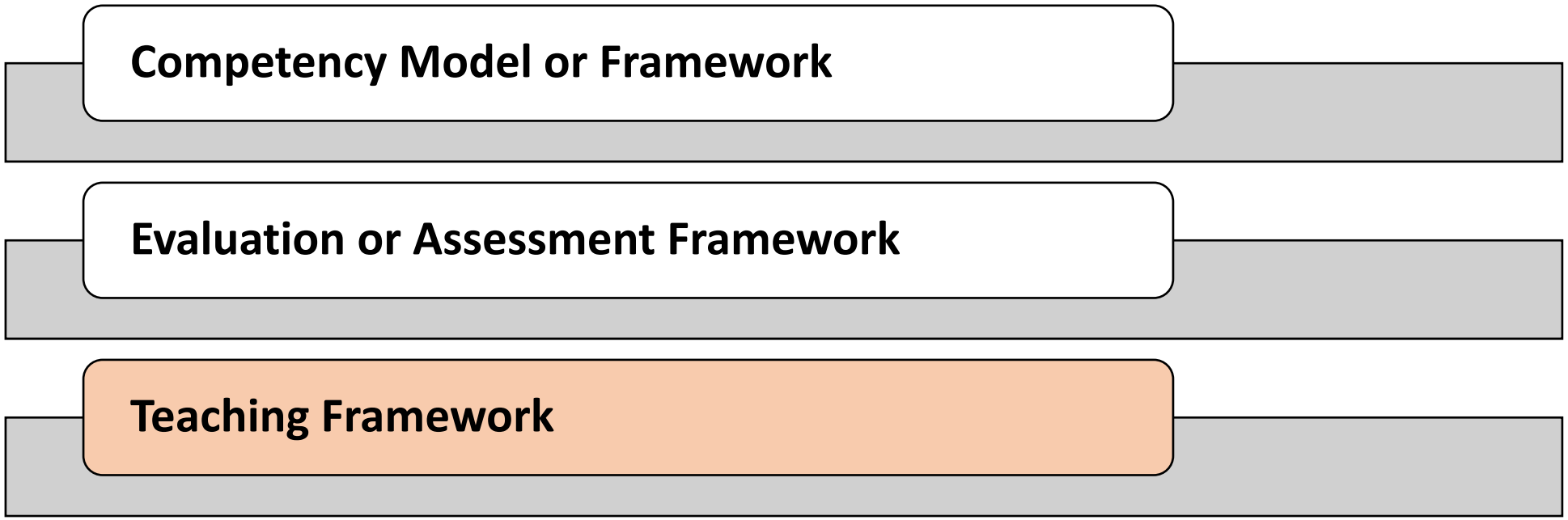
Linn, R. L., & Miller, M. D. (2005). Measurement and assessment in teaching (9ºth ed.). New Jersey: Pearson Education.

https://assessment.tki.org.nz/content/download/6110/62612/version/1/file/A+hitchhikers+guide+to+validity.pdf

McHugh, 2012
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3900052/

Delmas, et.al., 2007 http://iase-web.org/documents/SERJ/SERJ6(2)_delMas.pdf

Ikhsanudin & Subal, 2012
https://iopscience.iop.org/article/10.1088/1742-6596/1097/1/012039/pdf

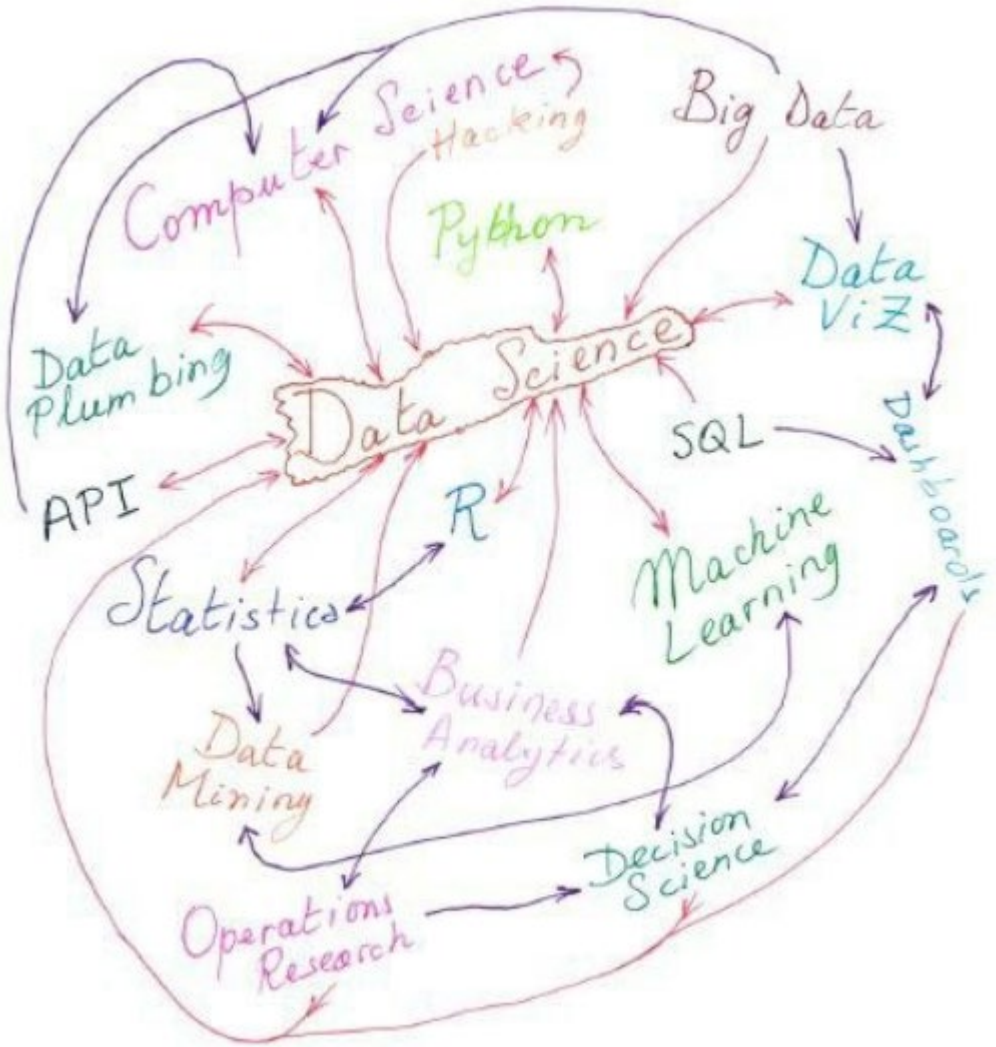

Competency Model or Framework
Evaluation or Assessment Framework
Teaching Framework

Developing Data Literacy

Individual	Organizational
Knowledge	Definitions
Skills / Competencies	Capacities
Attitudes	Practices

Developing Data Literacy

- Data Literacy Programs
- Teaching and learning methods
- Individual learning resources



https://www.pinterest.ca/pin/731905376935604058/?mt=login

Data Literacy Programs

Methods and Examples

- Models and designs for data literacy program development
- Extant Data literacy training programs and curricula

https://www2.deloitte.com/content/dam/Deloitte/ca/Documents/audit/ca-audit-abm-scotia-insights-from-impact-2018.pdf Deloitte 2018

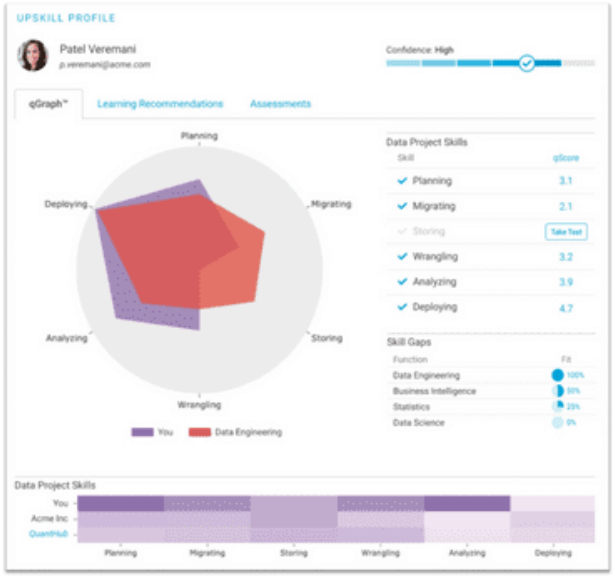
Also: Five Basic Principles for Upskilling HR in People Analytics, Bersin, Deloitte Consulting LLP / Madhura Chakrabarti, 2018.

https://community.alteryx.com/t5/Women-of-Analytics/To-require-Data-Literacy-for-every-university-student-what-does/td-p/542076

Method

A Roadmap for Creating a Data Literacy Program

Individual and team data literacy learning and development plans

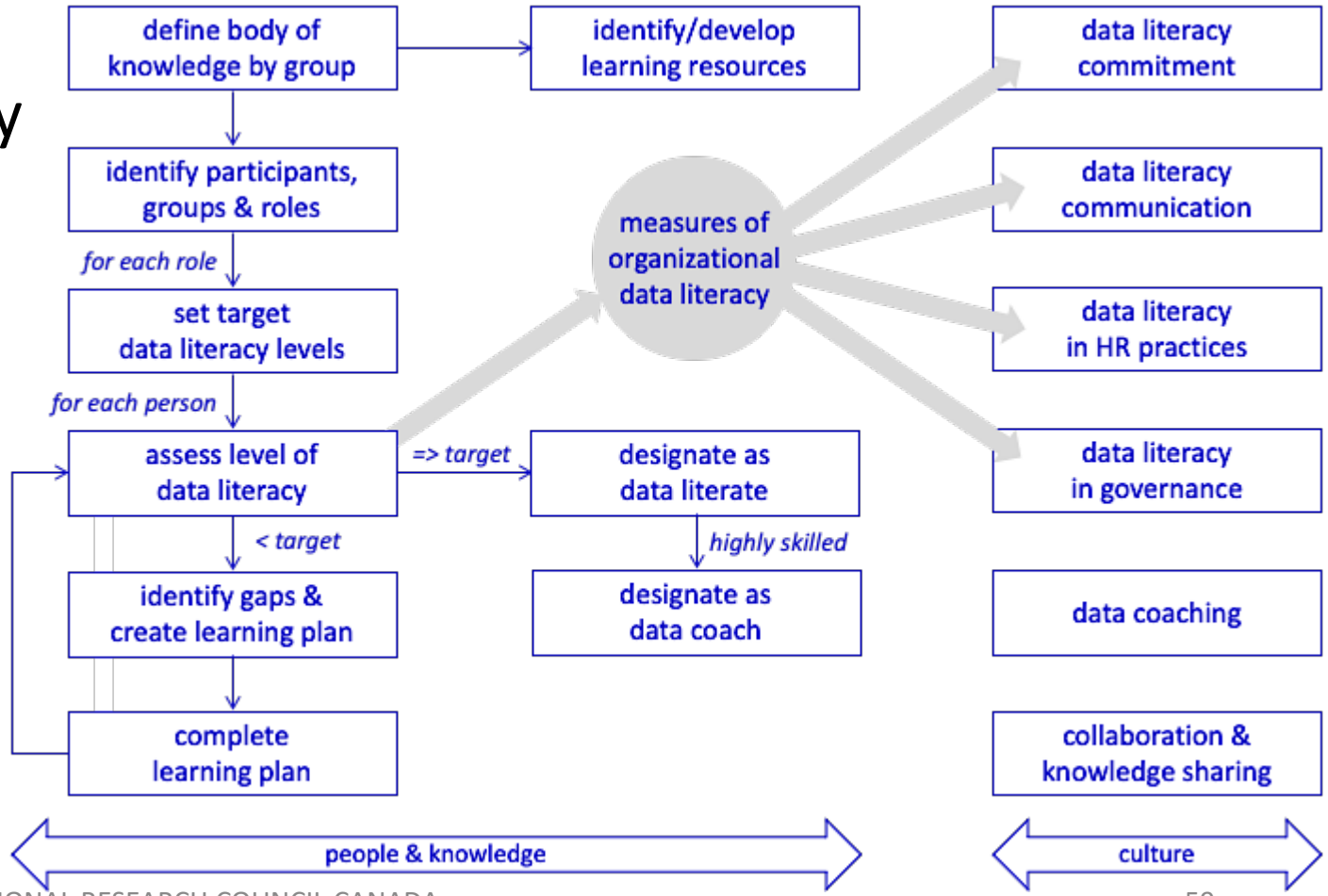


Matt Cowell, QuantHub https://quanthub.com/data-literacy-program/

Method

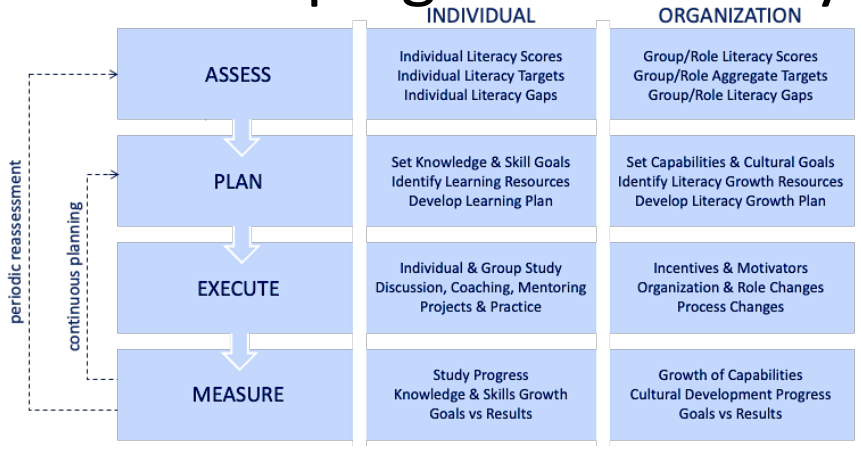
The Data Literacy Imperative Part I: Building a Data Literacy Program

Dave Wells, Eckerson Group
https://www.eckerson.com/articles/the-data-literacy-imperative-part-i-building-a-data-literacy-program

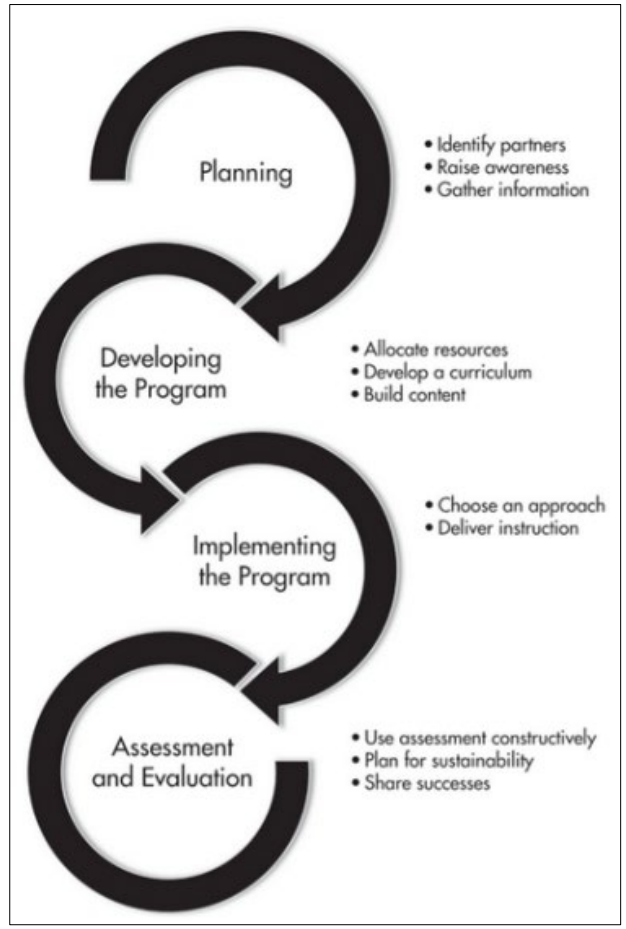


Method

The Data Literacy Imperative - Part IV: Developing Data Literacy



Dave Wells, Eckerson Group
https://www.eckerson.com/articles/the-data-literacy-imperative-part-iv-developing-data-literacy



Wright, et.al., 2015
http://www.datainfolit.org/dilguide/

Data Literacy Project (no longer extant) https://web.archive.org/web/20211222131031/http://dataliteracy.ca/about-this-data-literacy-project/

https://events.educause.edu/educause-institute/data-literacy-institute/2022/online-1

https://thedataliteracyproject.org/

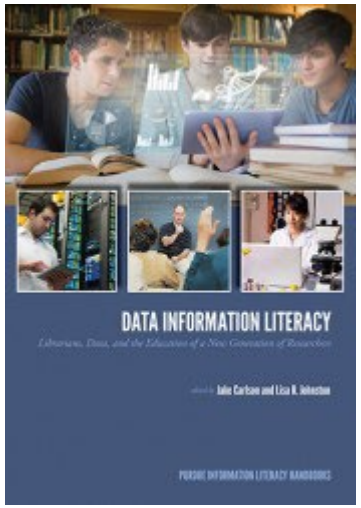
https://thedataliteracyproject.org/posts/establishing-a-competency-based-approach-to-data-literacy

https://www.linkedin.com/company/dataliteracyproject/

https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1011&context=lib_fspres

https://docs.lib.purdue.edu/dilcs/

http://www.datainfolit.org/publications/



http://www.thepress.purdue.edu/titles/format/9781612493527

Example

UNESCO Digital Literacy Global Framework

Six of the national frameworks (Costa Rica, India, Kenya, Philippines, Chile and British Columbia (Canada)) that are most clearly written with regard to the competency areas, as well as the three enterprise frameworks to map against the DigComp 2.0 framework

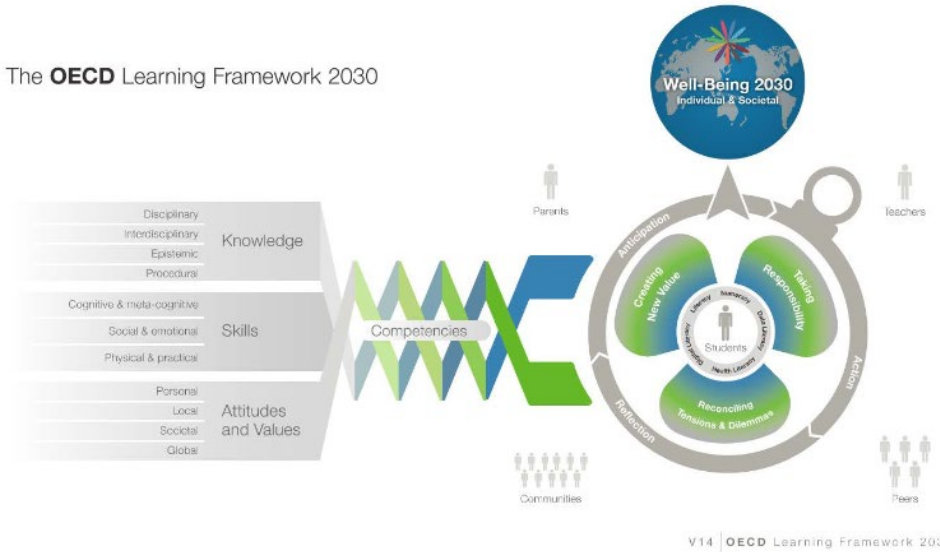
Published by the UNESCO Institute for Statistics, is part of the Global Alliance to Monitor Learning (GAML), a Digital Literacy Global Framework was developed, http://uis.unesco.org/en/blog/digital-literacy-skills-framework-measure

A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2 http://uis.unesco.org/sites/default/files/documents/ip51-global-framework-reference-digital-literacy-skills-2018-en.pdf

Recommendations on Assessment Tools for Monitoring Digital Literacy within UNESCO DLGF http://gaml.uis.unesco.org/wp-content/uploads/sites/2/2018/12/4.4.2_02-Assessment-tools-for-monitoring-digital-literacy.pdf

Example

OECD on Skills Development



It will be important to:

- Involve stakeholders in the design of integrated information systems
- Use information management systems to inform rather than automate decisions that should be taken by stakeholders themselves.
- Make use of different kinds of data

OCED has a website on skills development at https://www.oecd.org/skills/

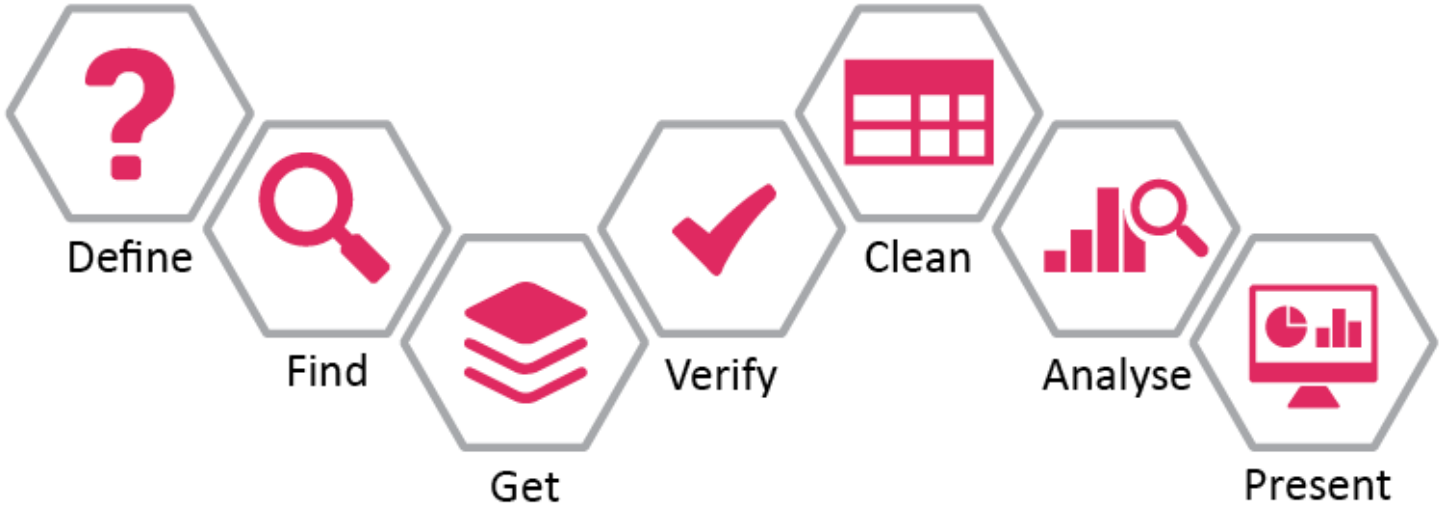
Although not focused on Data Literacy, this report has some policy on dealing with stakeholders*: Strengthening the Governance of Skills System: a self-assessment tool.* https://www.oecd.org/skills/centre-for-skills/Strengthening_the_Governance_of_Skills_Systems_Self_Assessment_Tool.pdf

Survey of Adult Skills (PIAAC): Full selection of indicators

Image: https://www.oecd.org/education/2030/E2030%20Position%20Paper%20(05.04.2018).pdf

Teaching and Learning Methods

- Pedagogical methods to teach or support data literacy training
- Specific trials of different methods in various learning contexts



https://www.stateofopendata.od4d.net/chapters/issues/data-literacy.html

Methods

Overall recommendations

Recommendations for statistical literacy instruction may apply more broadly to data literacy in general

Guidelines for Assessment and Instruction in Statistics Education (GAISE)

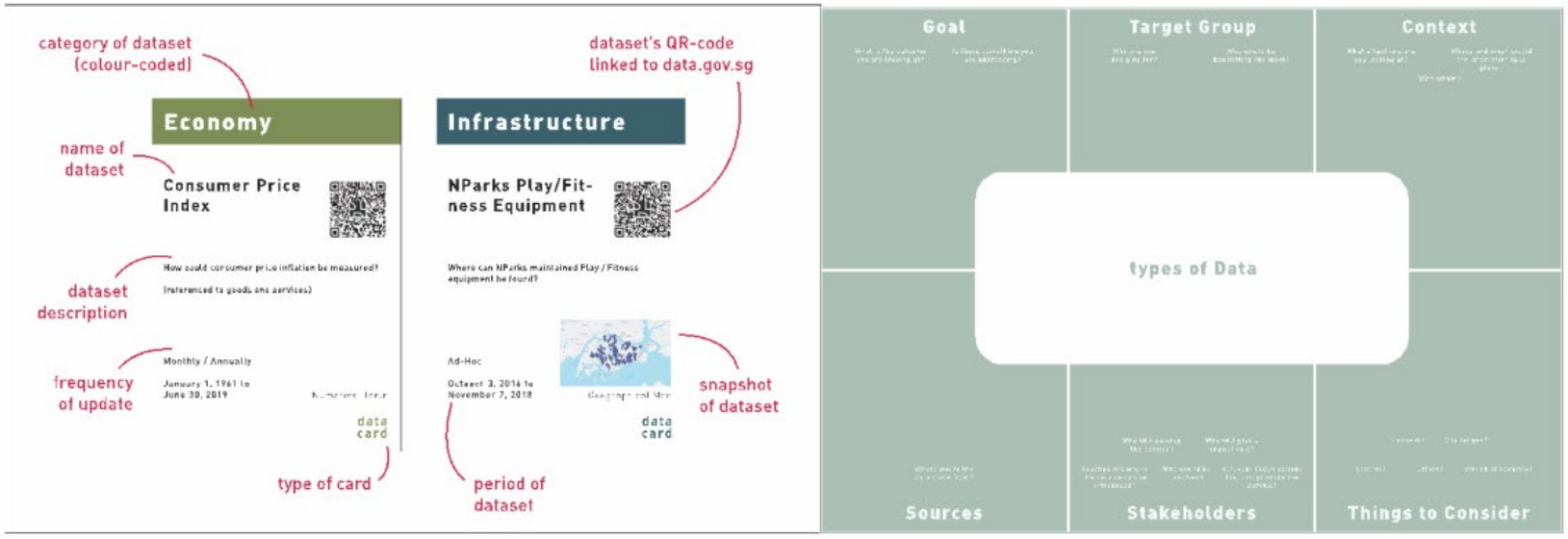
Robert Carver, et.al.. (2016). Guidelines for Assessment and Instruction in Statistics Education (GAISE) College Report. American Statistical Association. https://www.amstat.org/docs/default-source/amstat-documents/gaisecollege_full.pdf

Anna Bargagliotti, et.al. (2020). Pre-K–12 Guidelines for Assessment and Instruction in Statistics Education II (GAISE II). American Statistical Association. https://www.amstat.org/docs/default-source/amstat-documents/gaiseiiprek-12_full.pdf

1. Teach statistical thinking.
   - Teach statistics as an investigative process of problem-solving and decision-making.
   - Give students experience with multivariable thinking.
2. Focus on conceptual understanding.
3. Integrate real data with a context and purpose.
4. Foster active learning.
5. Use technology to explore concepts and analyze data.
6. Use assessments to improve and evaluate student learning.

Methods

Datastorming

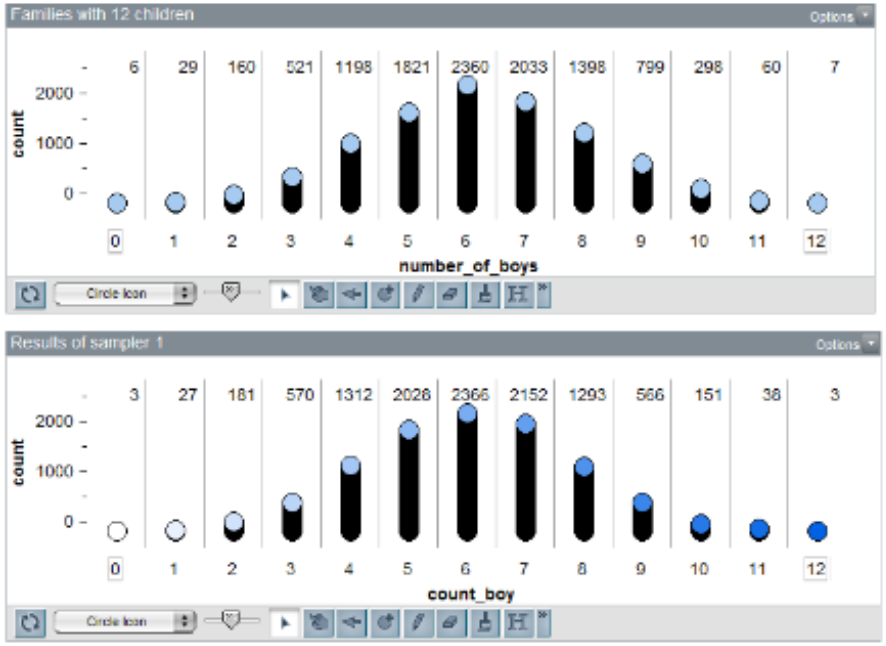


Description of 'datastorming', a way to think about using how to create designs using data. "To overcome their unfamiliarity to data, we aimed to craft abstract data into hands-on design materials in the form of cards”

Datastorming: Crafting Data into Design Materials for Design Students’ Creative Data Literacy
Delia Yi Min Lim, Christine Ee Ling Yap, Jung-Joo Lee, C&C '21: Creativity and Cognition
https://dl.acm.org/doi/pdf/10.1145/3450741.3465246

Methods

Simulations and Interactive Technologies

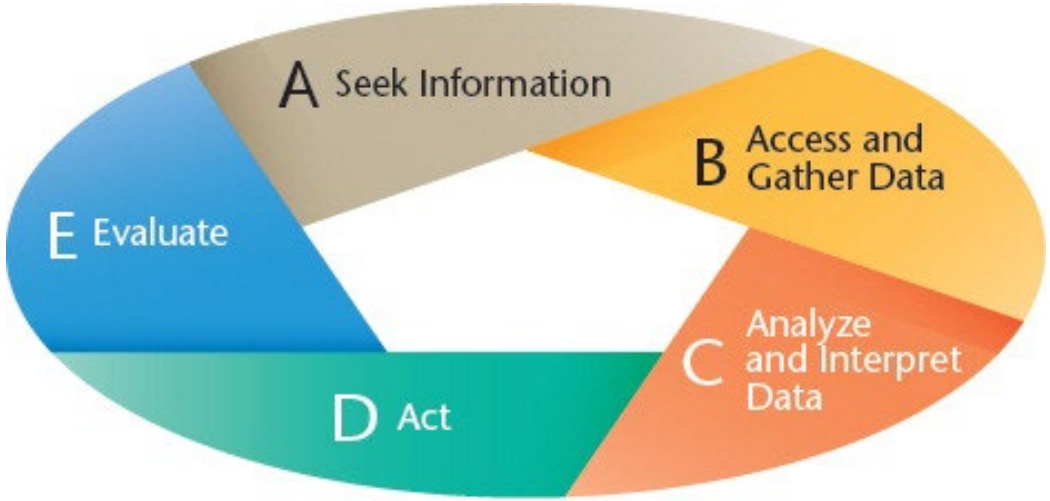


TinkerPlots
https://www.tinkerplots.com/

Rolf Biehler, Daniel Frischemeier, Susanne Podworny. Elementary preservice teachers' reasoning about modeling a family factory with TinkerPlots - A pilot study
Statistics Education Research Journal,
http://iase-web.org/documents/SERJ/SERJ16%282%29_Biehler.pdf

Methods

Case-Based Teaching Method

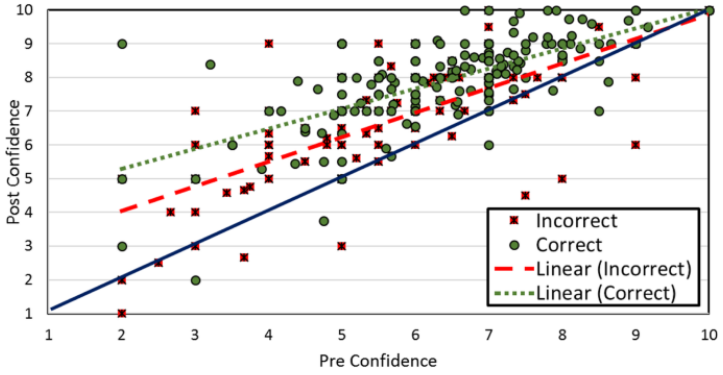


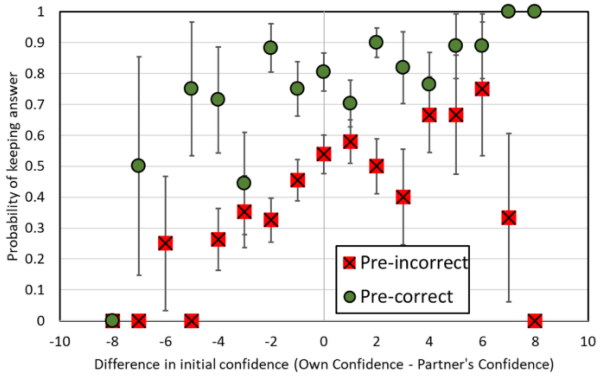
Case-based teaching as “an active learning strategy in which students read and discuss complex, real-life scenarios that call on their analytical thinking skills and decision--making”

Derek R. Riddle, Jori S. Beck, Joseph John Morgan, Nancy Brown, Heather Whitesides. (2017). Making a case for case-based teaching in data literacy. Kappa Delta Pi Record. https://www.tandfonline.com/doi/full/10.1080/00228958.2017.1334479
https://digitalcommons.odu.edu/cgi/viewcontent.cgi?article=1104&context=teachinglearning_fac_pubs

Methods

Utilising affordances in real-world data.



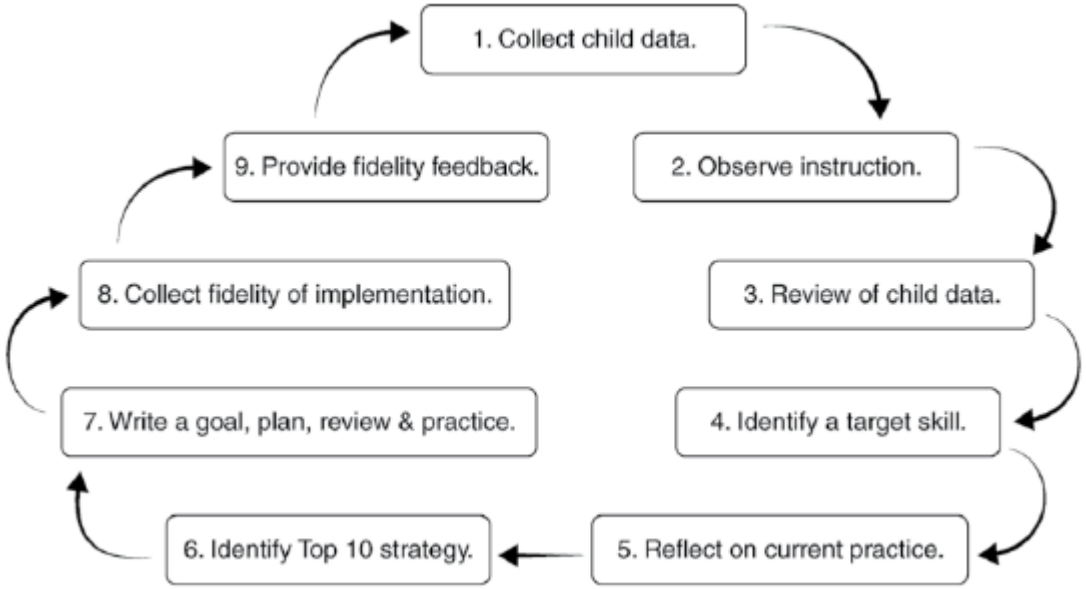


Based on the Teaching for Statistical Literacy Hierarchy, analyzes statistical literacy lessons that use real-world data from the perspective of the affordances in the data presentation.

Helen L. Chick, Robyn Pierce, International Journal of Science and Mathematics Education. 2022. Teaching for statistical literacy: Utilising affordances in real-world data. International Journal of Science and Mathematics Education. https://link.springer.com/article/10.1007/s10763-011-9303-2

Methods

Literacy Data-Driven Decisions



Requirements:

- Expertise in data collection
- Management of variable environment
- Need space & time for the process
- Need to ensure process fidelity

Mary Abbott, et.al. (2017). A Team Approach to Data-Driven Decision-Making Literacy Instruction in Preschool Classrooms: Child Assessment and Intervention Through Classroom Team Self-Reflection. Young Exceptional Children. https://files.eric.ed.gov/fulltext/EJ1151410.pdf

Resources

Types of Resources:

- Lessons and Lesson Plans
- Help Sheets and Templates
- Course and Video Libraries
- Performance Support Tools

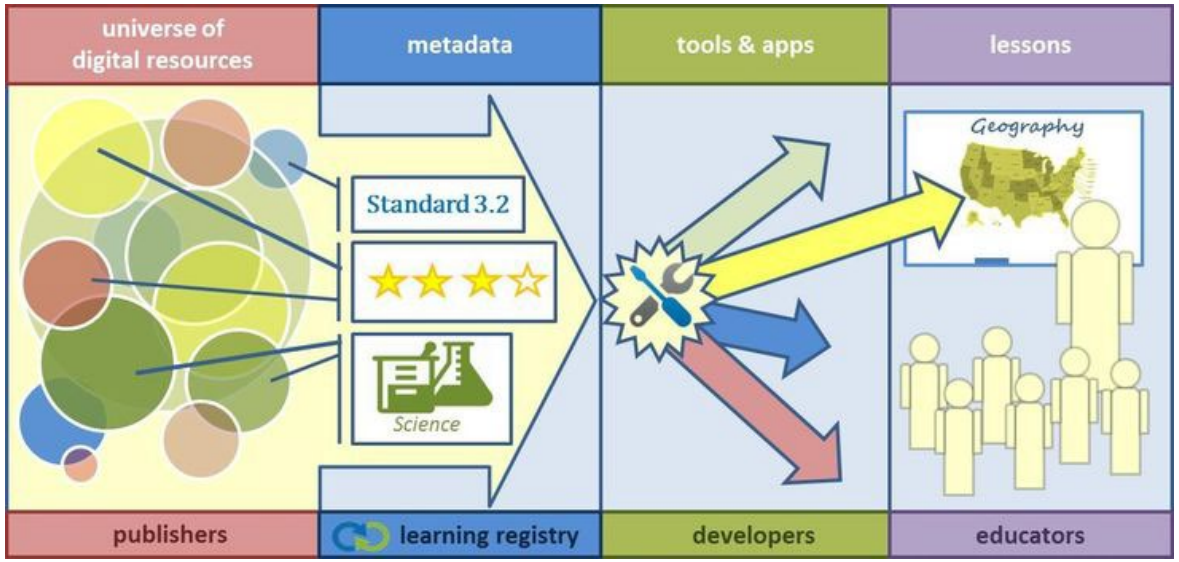
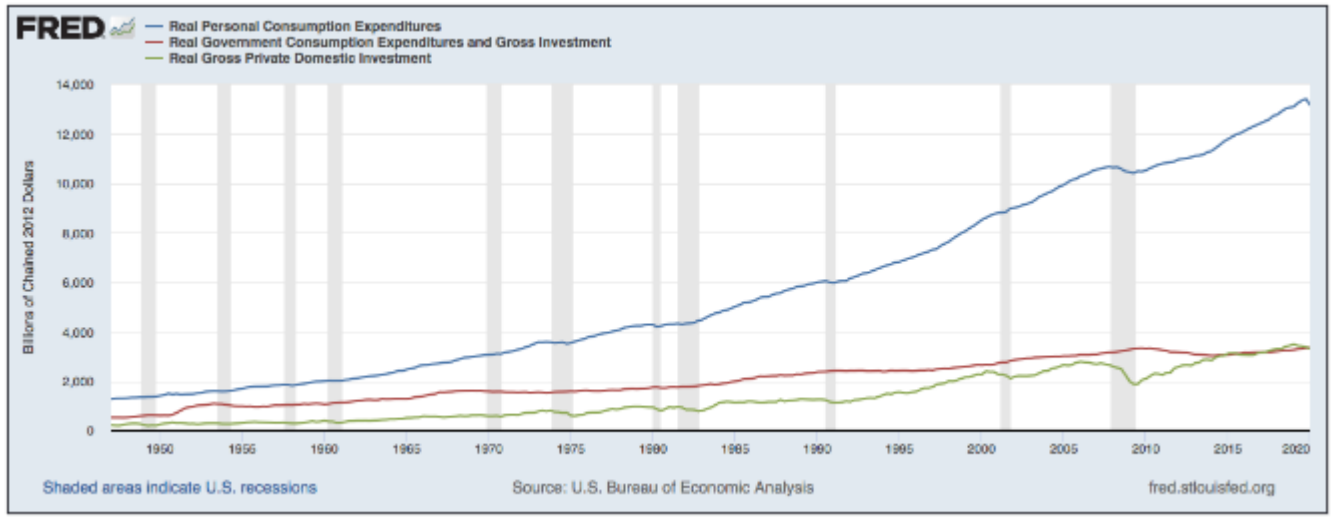


Image: https://www.pinterest.ca/pin/332984966170591583/

Resources

Lessons for Teaching Data Literacy

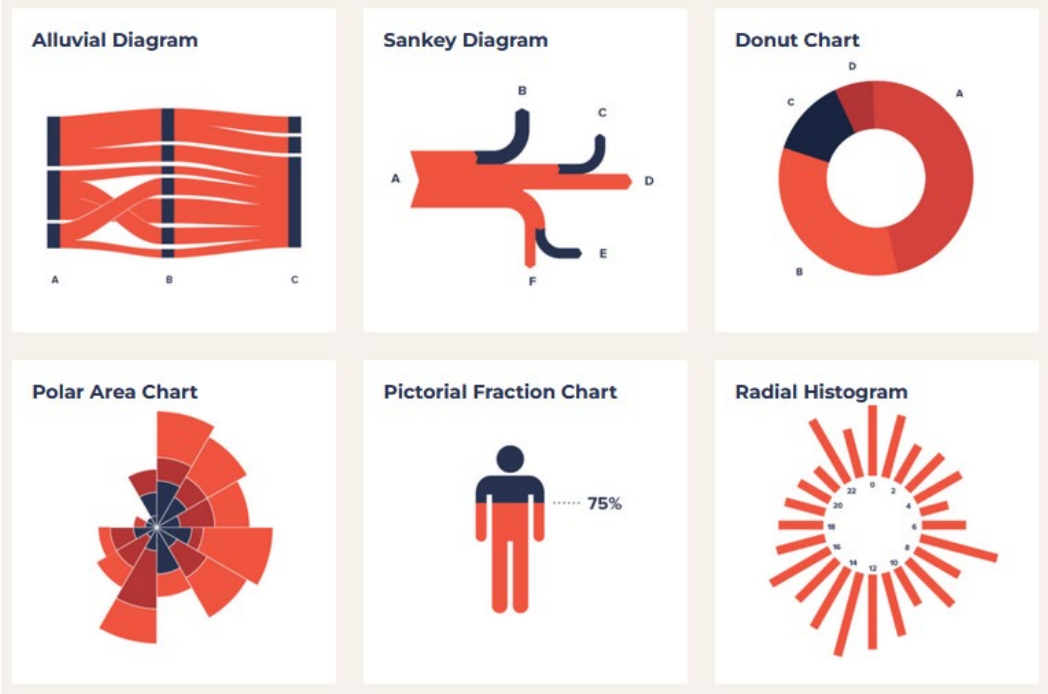


Federal Reserve Bank of St. Louis. Each lesson reviews data interpretation, analysis, and/or presentation concepts in detail, and is written in an accessible manner Sample lesson here.

https://www.stlouisfed.org/education/lessons-for-teaching-data-literacy

Resources

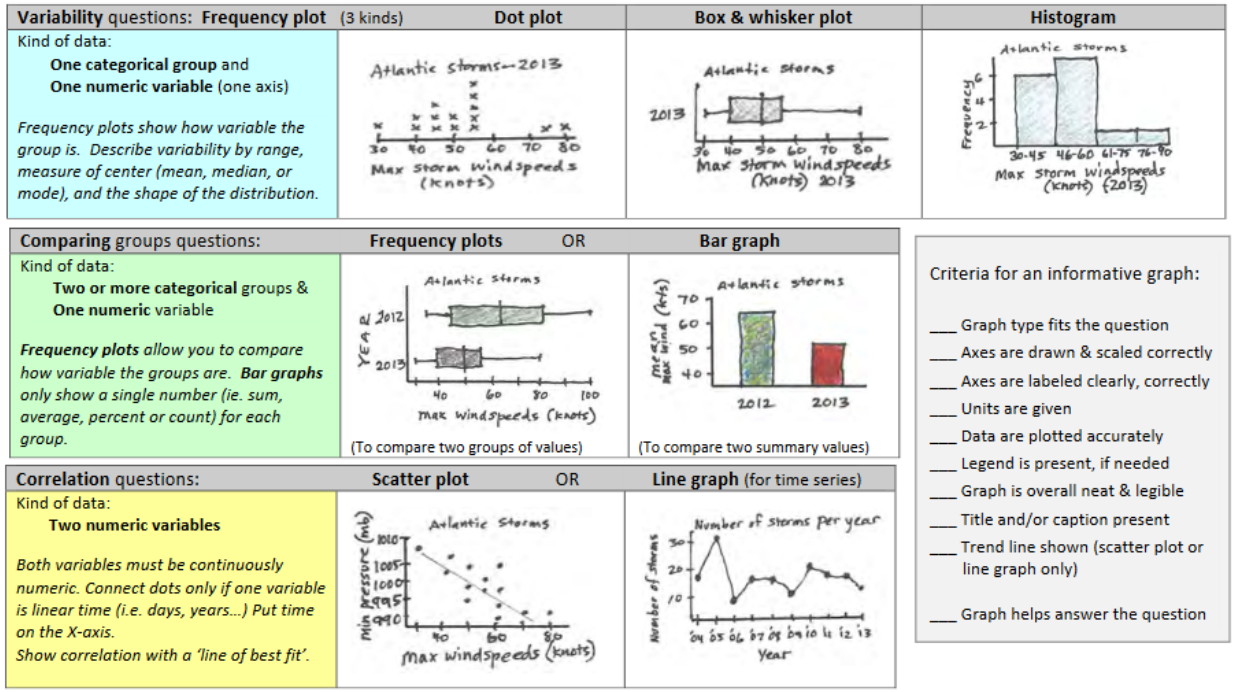
Data Visualization Project



Set of common data visualization formats or templates, with an accompanying instruction page for each one.
https://datavizproject.com/

Resources

Data Analysis Worksheet



Variability questions: **Frequency plot** (3 kinds) | **Dot plot** | **Box & whisker plot** | **Histogram**

Kind of data:
One categorical group and
One numeric variable (one axis)

Frequency plots show how variable the group is. Describe variability by range, measure of center (mean, median, or mode), and the shape of the distribution.

Comparing groups questions: **Frequency plots** OR **Bar graph**

Kind of data:
Two or more categorical groups &
One numeric variable

***Frequency plots** allow you to compare how variable the groups are. **Bar graphs** only show a single number (ie. sum, average, percent or count) for each group.*

(To compare two groups of values) (To compare two summary values)

Correlation questions: **Scatter plot** OR **Line graph** (for time series)

Kind of data:
Two numeric variables

Both variables must be continuously numeric. Connect dots only if one variable is linear time (i.e. days, years…) Put time on the X-axis.
Show correlation with a 'line of best fit'.

Criteria for an informative graph:

___ Graph type fits the question
___ Axes are drawn & scaled correctly
___ Axes are labeled clearly, correctly
___ Units are given
___ Data are plotted accurately
___ Legend is present, if needed
___ Graph is overall neat & legible
___ Title and/or caption present
___ Trend line shown (scatter plot or line graph only)

___ Graph helps answer the question

Van Andel Education Institute, Mar 23, 2022
https://vaei.vai.org/wp-content/uploads/sites/6/2018/10/Data-Analysis-Strategies.pdf

Resources…

Statistics Canada Data Literacy Training Products

- Data **used to create statistical information** that meet the required criteria upon which to build data story.
- This means they are…
  - ✓ Good quality
  - ✓ Valid for desired use
  - ✓ Edited to include only key findings
  - ✓ Properly sourced

20 Short-form Videos https://www150.statcan.gc.ca/n1/en/catalogue/89200006#wb-auto-2=

Resources

Kubicle Data Literacy courses

Subscription-based data literacy and data management course library (courses are series of videos)
https://kubicle.com/library

Resources

eLearning Curve

COURSES

IM Foundations

Data Quality

Data Governance

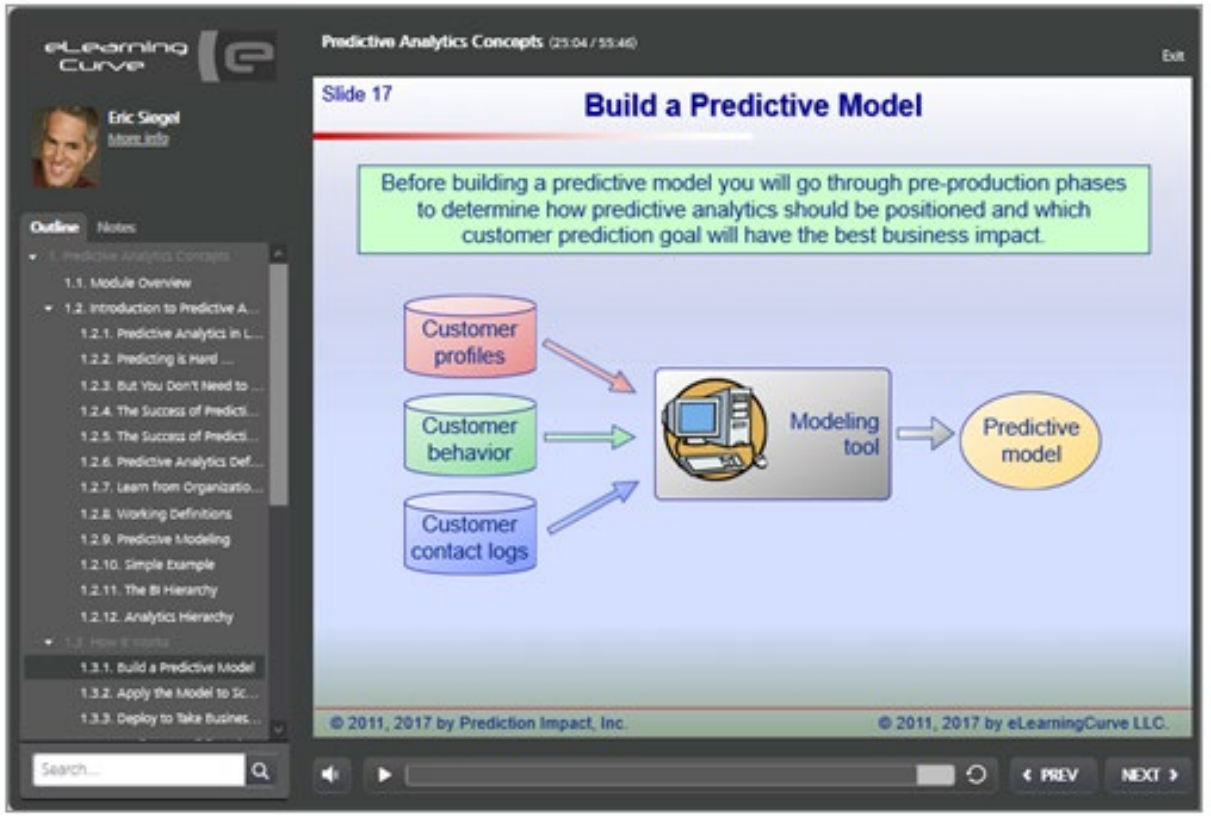
Data Stewardship

Master Data Management

Metadata Management

Business Intelligence & Analytics

Data Science



Course libraries.

https://ecm.elearningcurve.com/Online_Data_Stewardship_Education_s/119.htm

Resources

Performance Support

Cognos
https://www.ibm.com/training/data-analytics
https://www.ibm.com/training/search?query=*&trainingType=Badge

Qlik. https://www.informatec.com/sites/default/files/download-item/QlikEducationServices-CourseDiagram-2020.pdf

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THANK YOU

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