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Modelling in the German school curriculum

Carsten Schulte

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Past & Now

Past & Now

Modelling (~2005)

Norbert Breier

Peter Hubwieser

Marco Thomas

Ludger Humbert

Dieter Engbring

Ira Diethelm

Carsten Schulte

2008: Standards for CS Education

Modelling now???

Thomas, Marco: Modellbildung im Schulfach Informatik, 1999

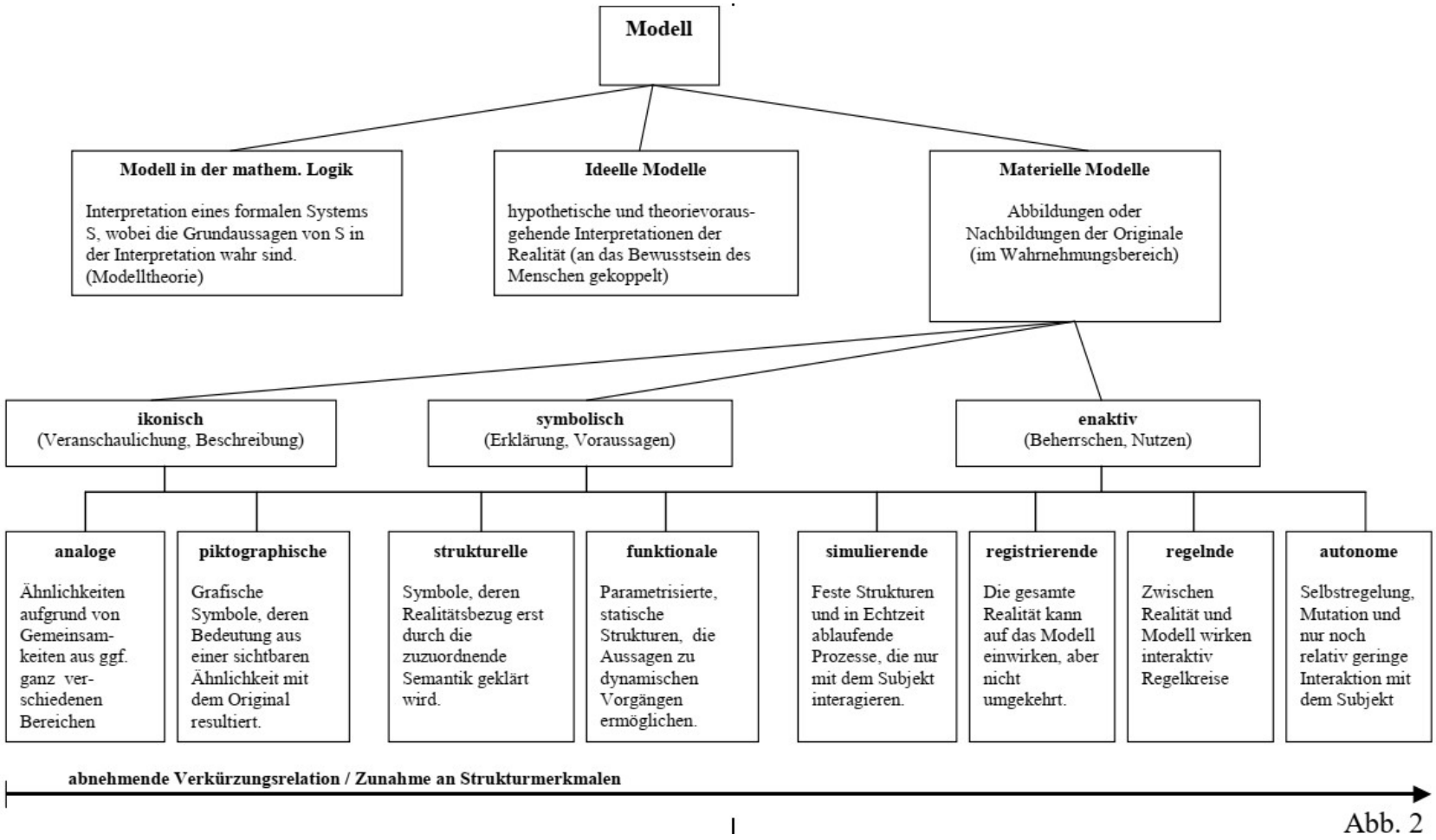

Abb. 2

Norbert Breier / Philosophy of CS

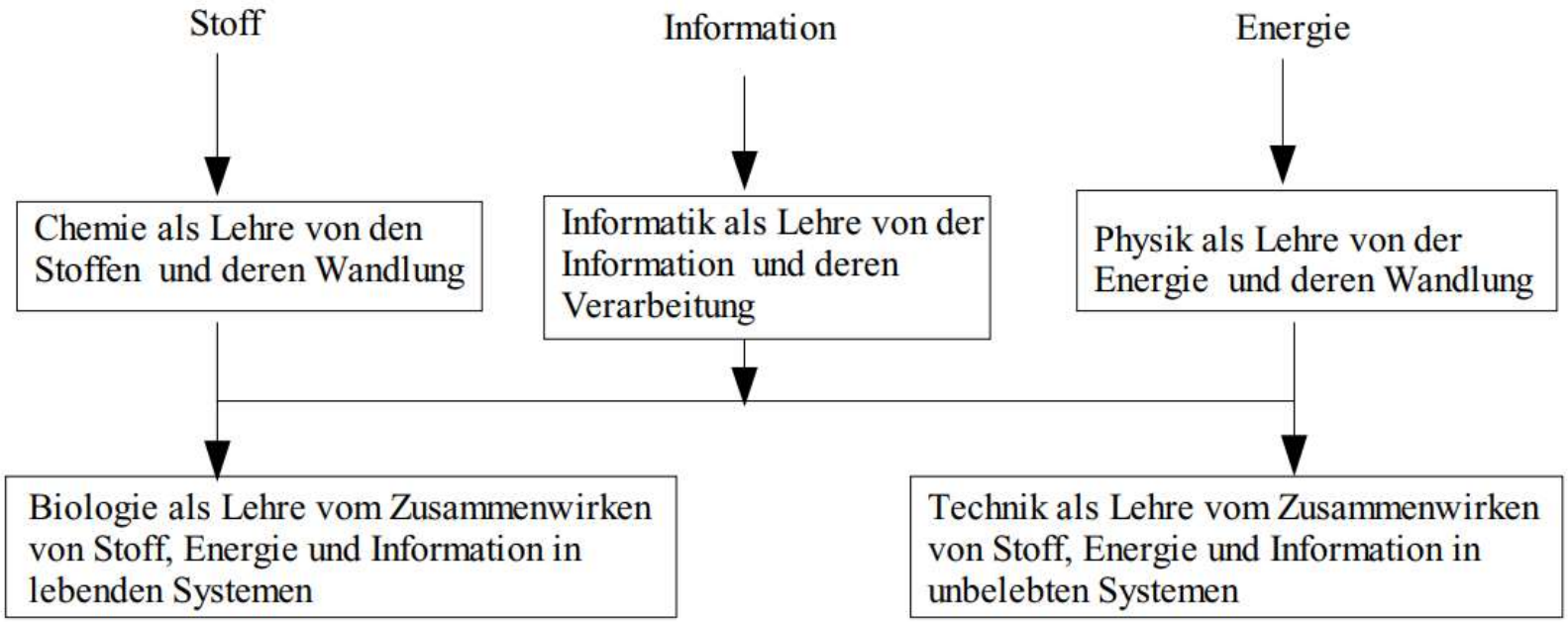

Abbildung 1

BREIER, Nobert, 2005. Informatik im Fächerkanon allgemein bildender Schulen–Überlegungen zu einem informationsorientierten didaktischen Ansatz. *Unterrichtskonzepte für informatische Bildung*. 2005

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General Role of CS

- Hubwieser, Thomas

BREIER, Norbert und Peter HUBWIESER, 2002. An information-oriented approach to informatical education. *Informatics in education*. 2002. Bd. 1, Nr. 1, S. 31–42. DOI 10.15388/infedu.2002.03

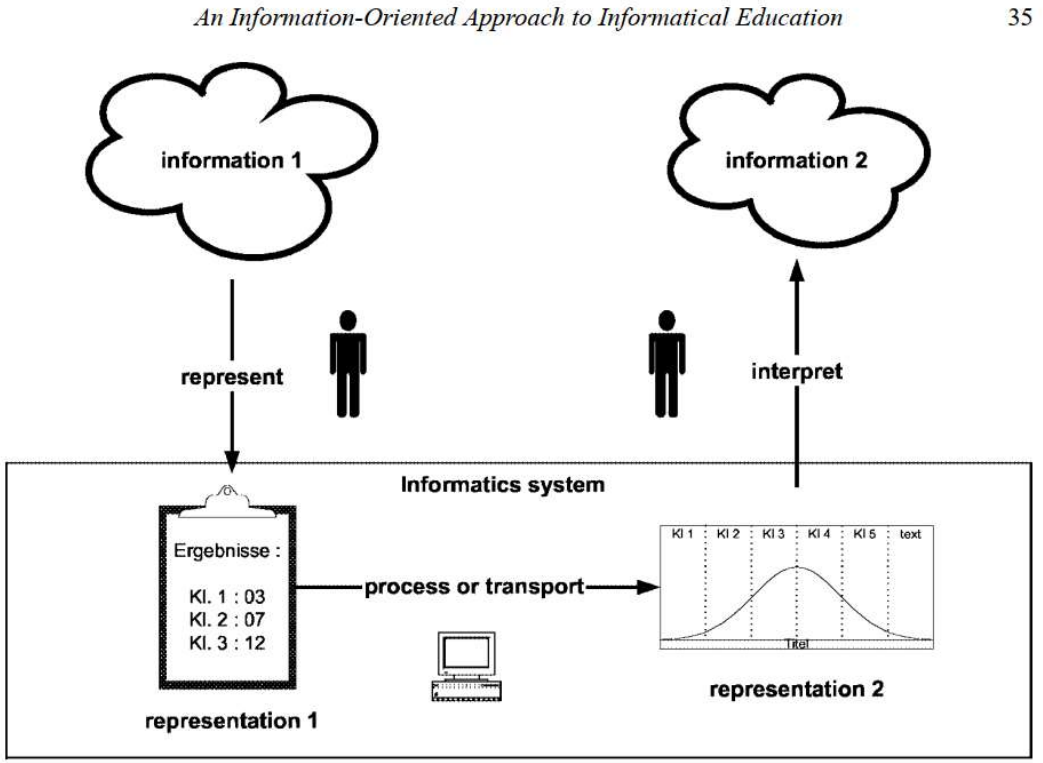


Fig. 1. Representation and transportation of information.

Modelling

- Humbert, Enbgring, Schulte ~2003

1.1.2.1 Direktes Mathematisieren

GREEFRATH, Gilbert, Gabriele KAISER, Werner BLUM und Rita BORROMEO FERRI, 2013. Mathematisches Modellieren – Eine Einführung in theoretische und didaktische Hintergründe. In: Rita BORROMEO FERRI, Gilbert GREEFRATH und Gabriele KAISER (Hrsg.), *Mathematisches Modellieren für Schule und Hochschule: Theoretische und didaktische Hintergründe* [online]. Wiesbaden: Springer Fachmedien. S. 11–37. Realitätsbezüge im Mathematikunterricht. [Zugriff am: 28 Februar 2021]. ISBN 978-3-658-01580-0. Verfügbar unter: https://doi.org/10.1007/978-3-658-01580-0_1

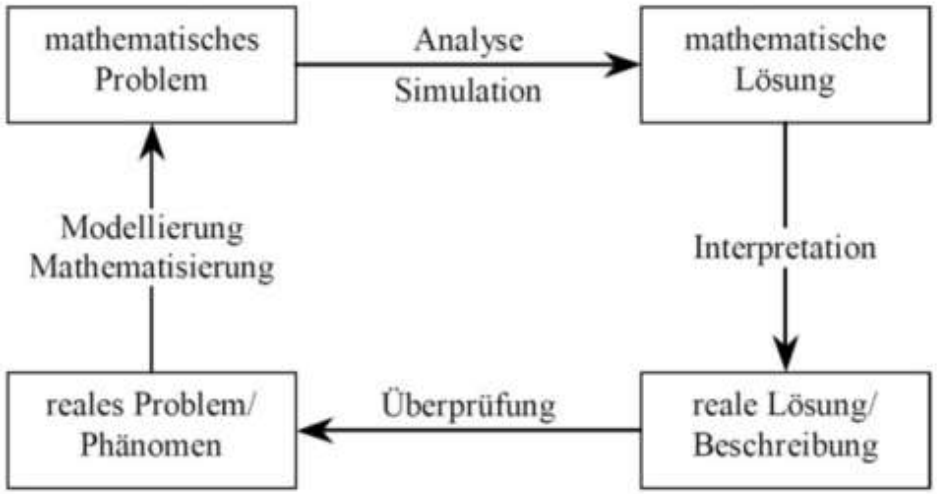
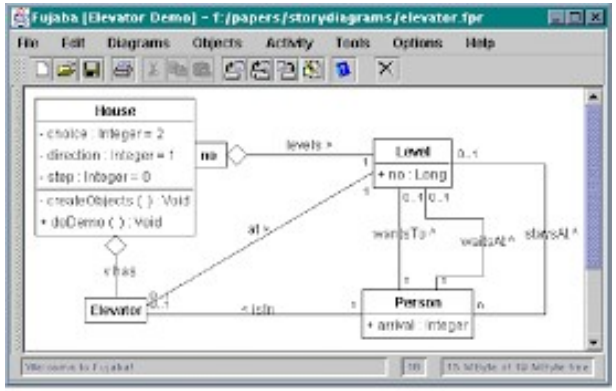


Abb. 1.4 Modellierungskreislauf nach Ortlieb (2004, S. 23)

(Strictly) Models First

- Diethelm
- OOM
- Schulte

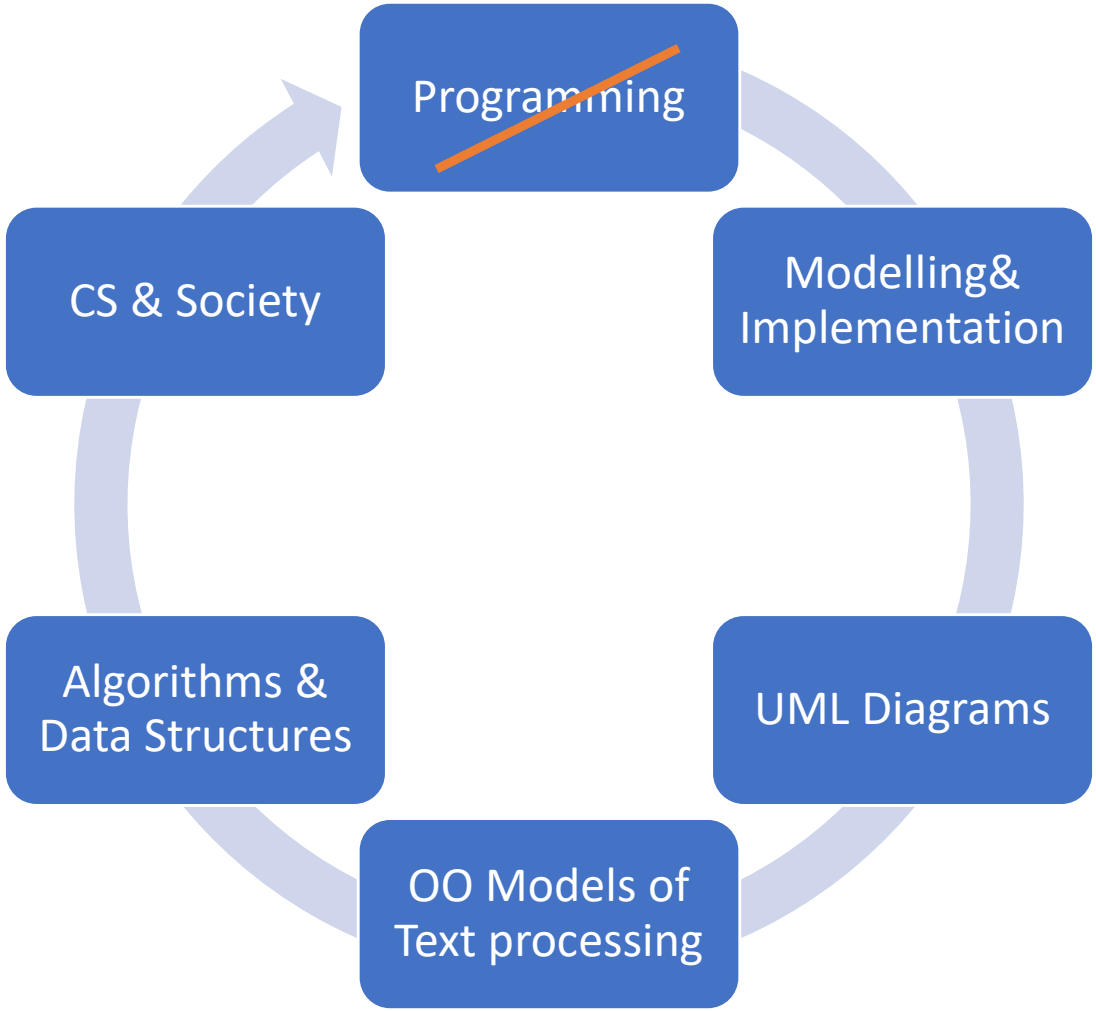
Abbildung 1: Objektspiel und Zetteltest



Ira Diethelm: "Strictly models and objects first" - Unterrichtskonzept und -methodik für objektorientierte Modellierung im Informatikunterricht, Dissertation 2011

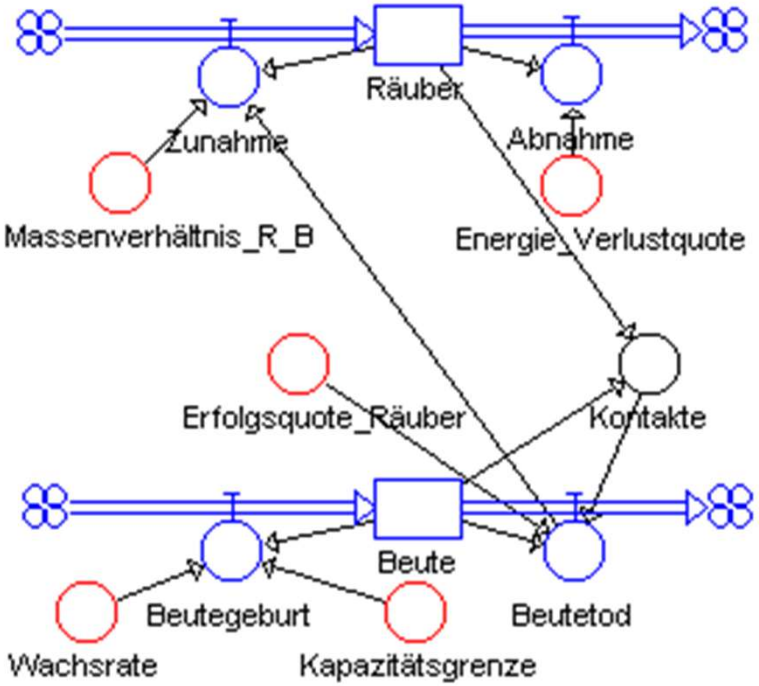
Educational Standards – The Practise

Since then???


Programming
Modelling& Implementation
UML Diagrams
OO Models of Text processing
Algorithms & Data Structures
CS & Society

Why not modelling and Simulation?

- ICT related??
- Too complicated?
- Too unimportant? (but: covid, climate change, development of housing and rents, traffic, future jobs…)



http://www.kohorst-lemgo.de/modell/modsimsequenz/modsim/t13/koh/raeubeu5.htm

Curriculum Beliefs

RC: Reine Chemie (Fundamental Chemistry)

- Theoretische Konzepte, insbesondere submikroskopische Deutungen, sind früh und vorrangig einzuführen, da sie die spätere Basis bereitstellen, Sachverhalte und Phänomene aus der Umwelt zu verstehen.

CTG: Chemie – Technik – Gesellschaft (Chemistry, Technology and Society)

- Der Zusammenhang von Chemie, Technik und Gesellschaft ist zu thematisieren, da es wesentliches Ziel des Unterrichts ist, die Lernenden zu befähigen, an Diskussionen und Entscheidungsprozessen innerhalb der Gesellschaft teilzuhaben, bei denen chemische Sachverhalte eine Rolle spielen.

CLW: Chemie als lebendige Wissenschaft (Knowledge Development in Chemistry)

- Lernende sollen lernen, dass sich Chemie in einem soziokulturellen Umfeld entwickelt hat und damit ein kulturelles Wissenssystem ist, das sich permanent verändert

MARKIC, Silvija, Ingo EILKS, Jan VAN DRIEL und Bernd RALLE, 2009. Vorstellungen deutscher Chemielehrkräfte über die Bedeutung und Ausrichtung des Chemielernens. In: *CHEMKON: Forum für Unterricht und Didaktik*. Wiley Online Library. 2009. S. 90–95

Curriculum Beliefs

Fundamental Chemistry

- Model as Formalization
- as (objective) representation of the world

Chemistry, Technology & Society

- Modelling as intentional Abbreviation / subjective representation
- As designed Artefact

Modelling & AI

Artificial Intelligence

Computers having human-like abilities / act as humans

Relevance

Big Data & Machine Learning

Architecture

Modelling & AI

Understanding AI

- Understanding the role of data
- Data as models
- Problem solving & modelling

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Automation: Computers taking over jobs of humans

GONZALEZ VAZQUEZ, et al., EUROPEAN COMMISSION, und JOINT RESEARCH CENTRE, 2019. *The changing nature of work and skills in the digital age.* [online]. [Zugriff am: 7 Dezember 2020]. ISBN 978-92-76-09206-3. Verfügbar unter: http://publications.europa.eu/publication/manifestation_identifier/PUB_KJNA29823ENN

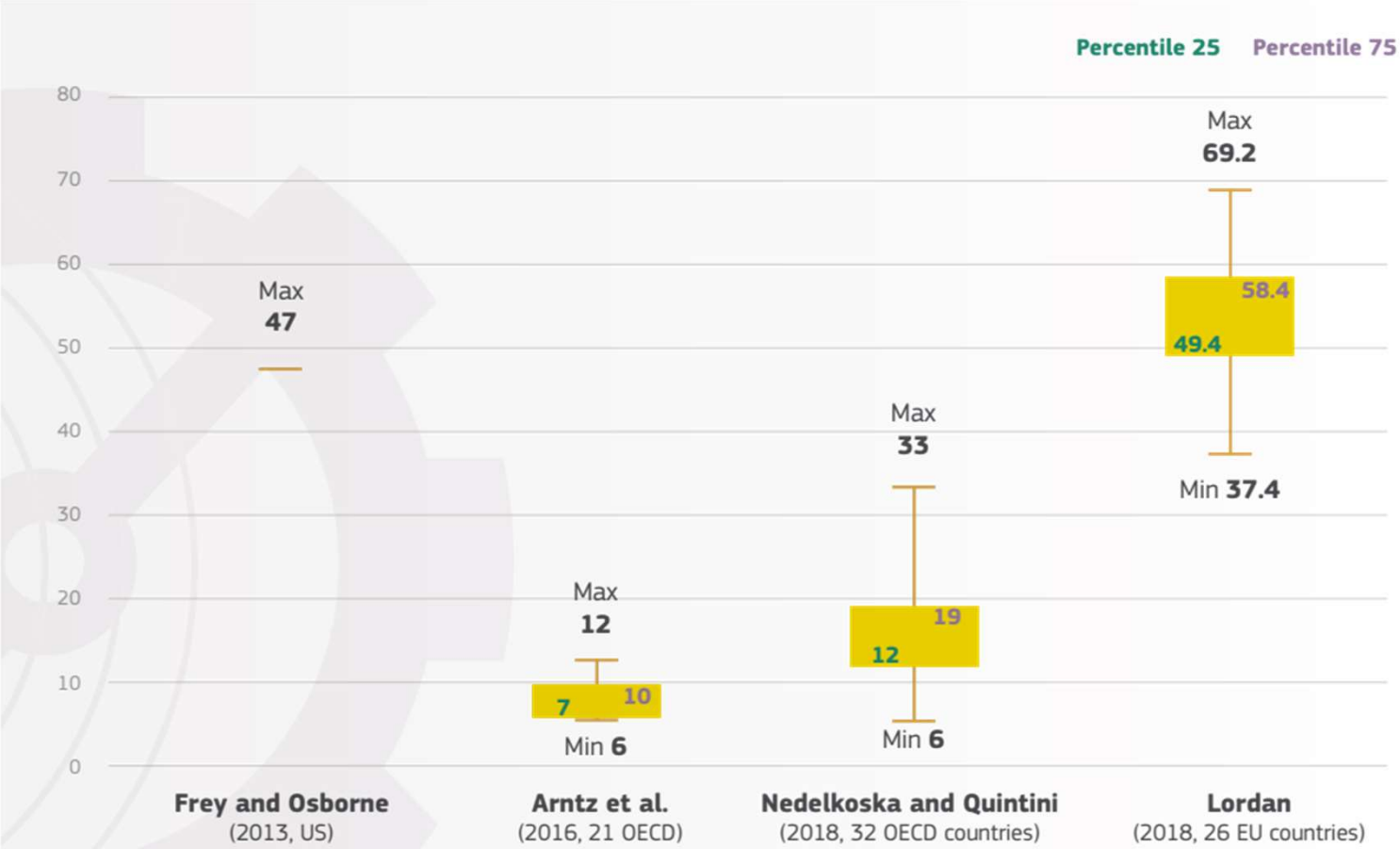


Figure 2: Estimates of the share of jobs at high risk of automation: variation across and within seminal studies

…in different areas

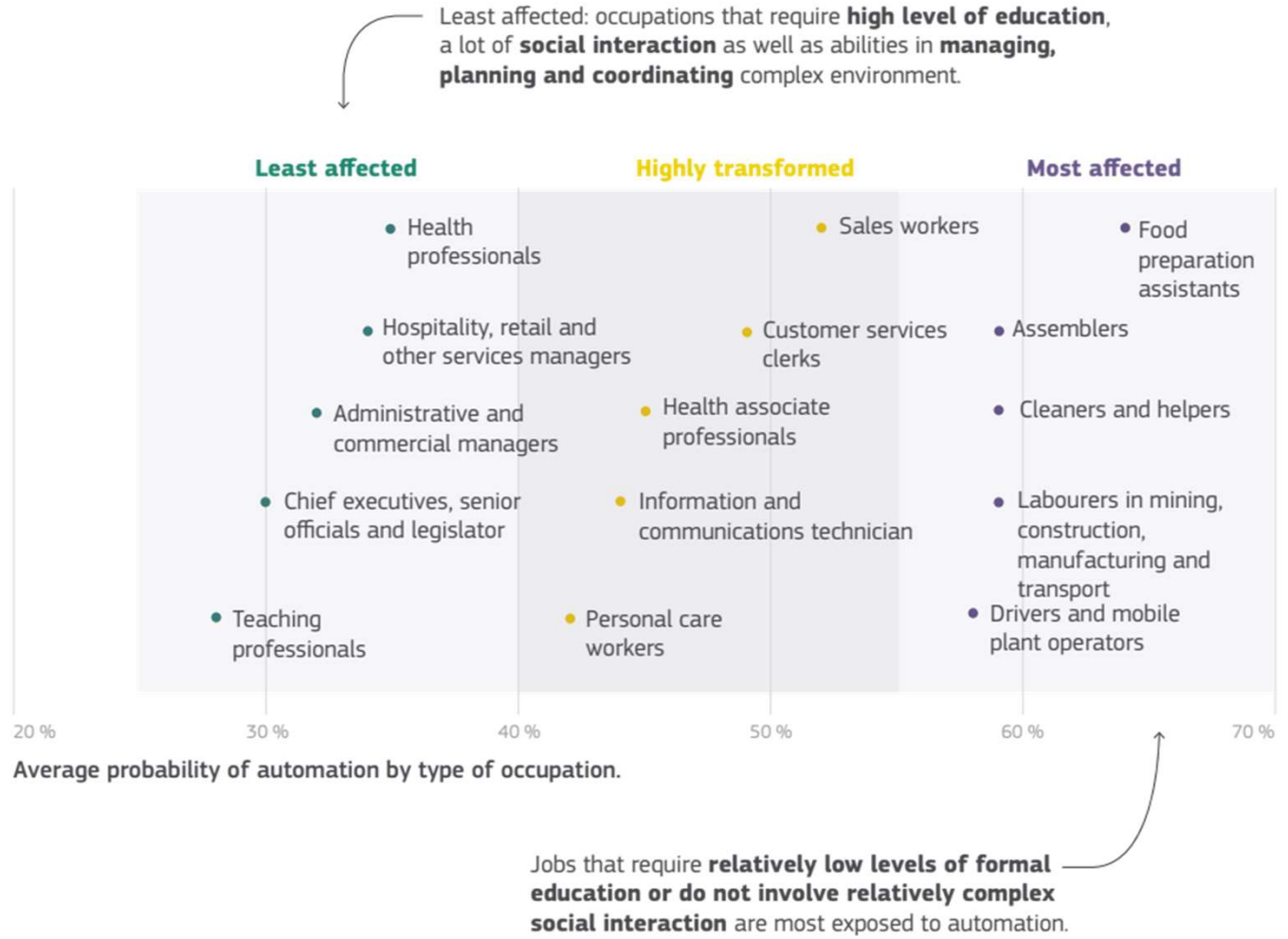
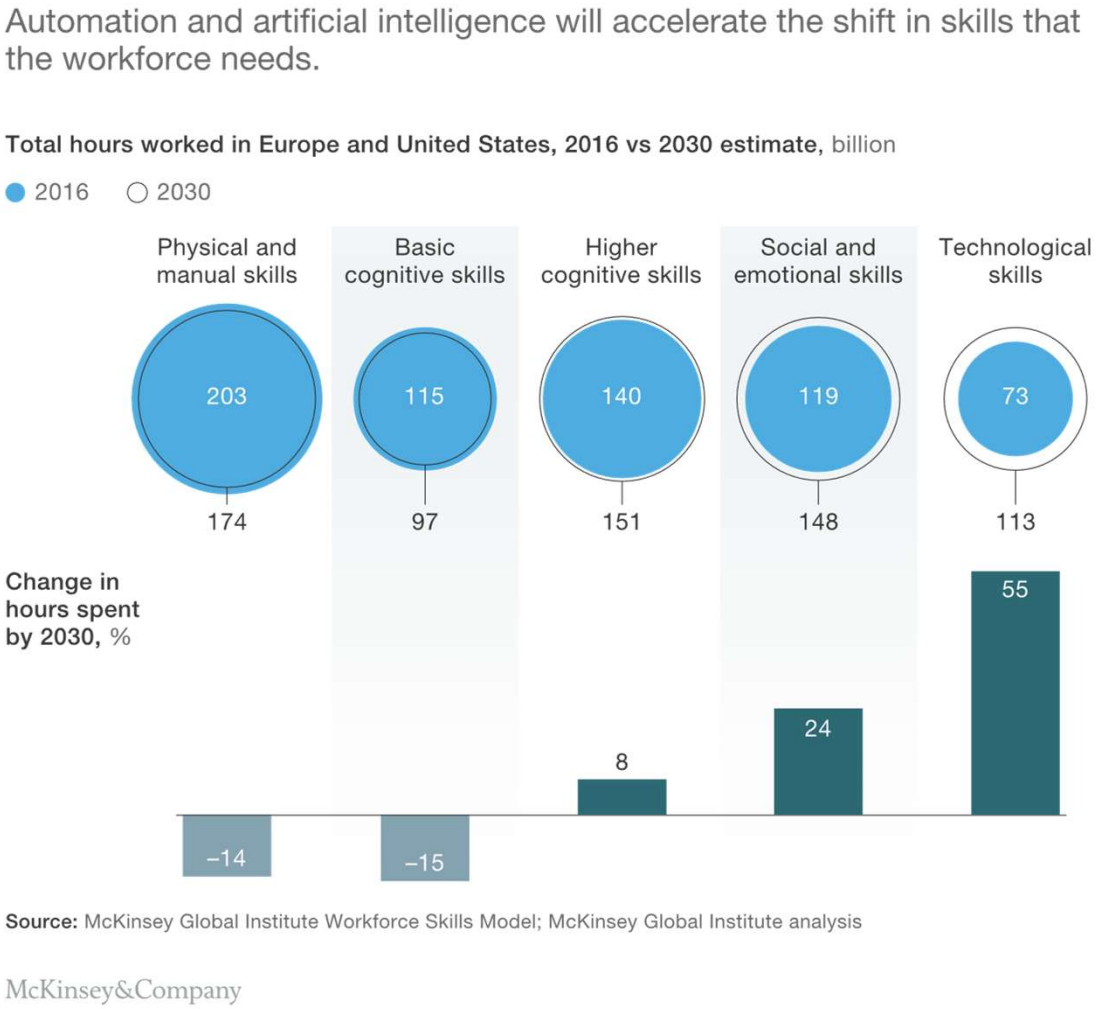


Figure 4: Occupations expected to be most and least affected by automation

GONZALEZ VAZQUEZ, et al., EUROPEAN COMMISSION, und JOINT RESEARCH CENTRE, 2019. *The changing nature of work and skills in the digital age.* [online]. [Zugriff am: 7 Dezember 2020]. ISBN 978-92-76-09206-3. Verfügbar unter: http://publications.europa.eu/publication/manifestation_identifier/PUB_KJNA29823ENN

AI, automation, and the future of work: Ten things to solve for (Tech4Good) | McKinsey, [kein Datum]. [online]. [Zugriff am: 24 Oktober 2021]. Verfügbar unter: https://www.mckinsey.com/featured-insights/future-of-work/ai-automation-and-the-future-of-work-ten-things-to-solve-for



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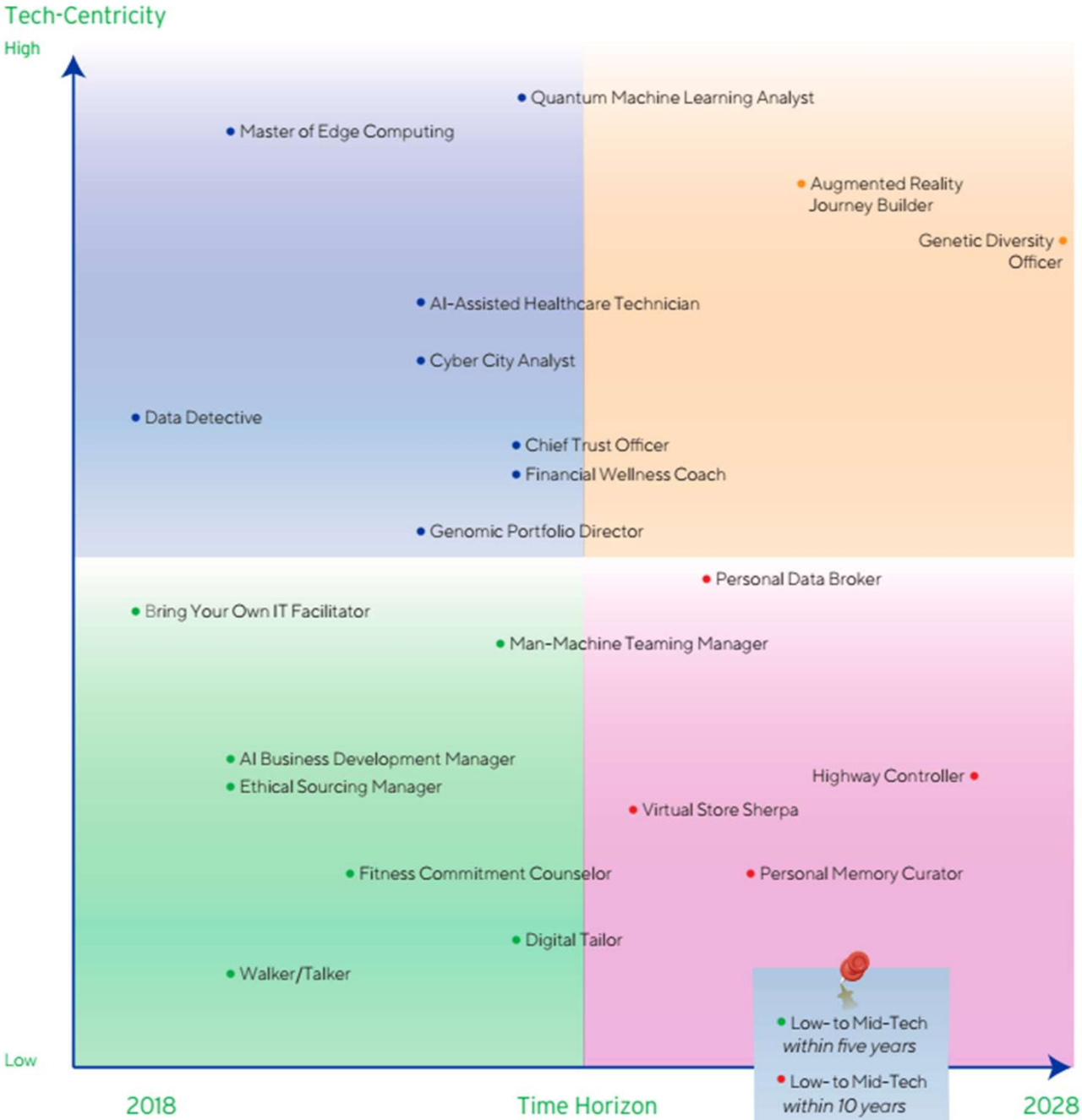
Job types



SMITH, B. und H. SHUM, 2018. *The Future Computed: Artificial Intelligence and its role in society.* [online]. Redmond: Microsoft. [Zugriff am: 1 Februar 2018]. ISBN 978-0-9997508-1-0. Verfügbar unter: https://msblob.blob.core.windows.net/ncmedia/2018/01/The-Future-Computed.pdf

https://trr318.uni-paderborn.de

in these jobs. For instance, as suggested by Wilson et al. (2017), some of the AI-related profiles sought by employers may be:

Trainers – workers managing large amounts of data and designing algorithms to train AI systems;

Modelling

Explainers – workers able to interpret the outcomes of AI systems;

Architects – workers responsible for organising AI systems and seizing opportunities for AI adoption;

Modelling

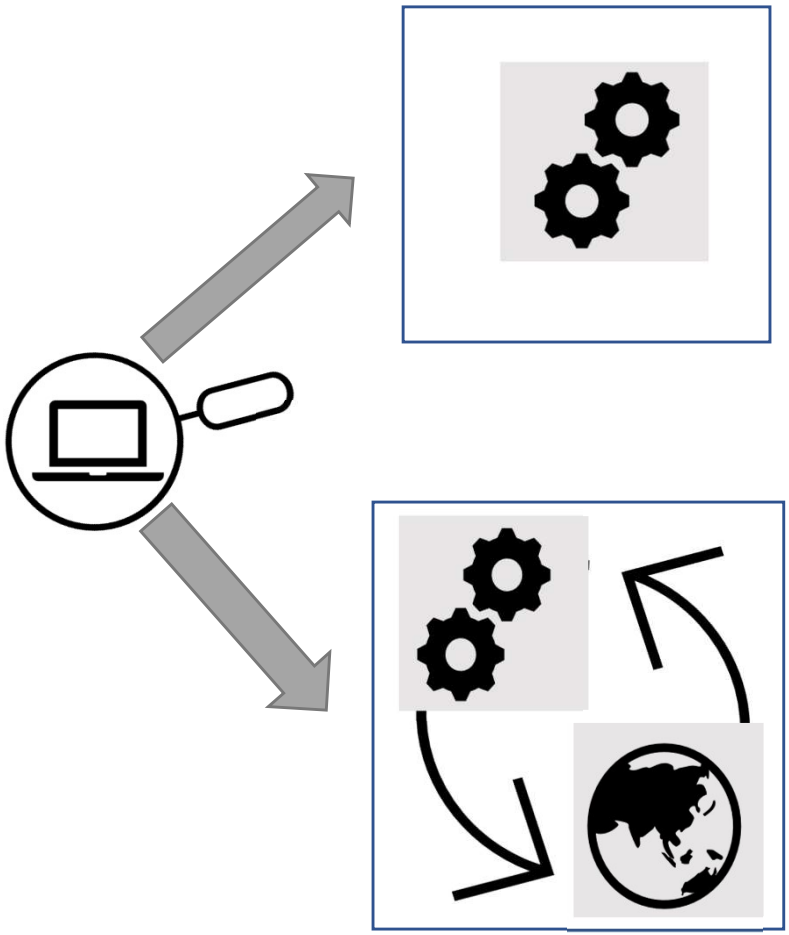
Ethicists – workers responsible for setting guidelines and ensuring they are upheld so that AI systems are accountable both internally and externally.

GONZALEZ VAZQUEZ, et al., EUROPEAN COMMISSION, und JOINT RESEARCH CENTRE, 2019. *The changing nature of work and skills in the digital age.* [online]. [Zugriff am: 7 Dezember 2020]. ISBN 978-92-76-09206-3. Verfügbar unter: http://publications.europa.eu/publication/manifestation_identifier/PUB_KJNA29823ENN

Attempt of an interpretation

- In Germany Modelling tied to Programming: Modelling & Implementation
- Also tied to engineering approach
  - Engineering vs science
  - Planning vs trial & error
- Modelling detached from simulation
  - Models of the problem vs modelling the world

Impact of change to ML: problem solving



$$x \rightarrow ALG \rightarrow y$$

Understanding the problem,
deriving a solution,
understanding the solution

$$Data \rightarrow Learner \rightarrow (x \rightarrow Model \rightarrow y)$$

~~Understanding the problem,~~
~~deriving a solution,~~
~~understanding the solution~~

Role of data

- Data vs code Picture
- Steps/Aspects of data processing
- Ubiquity of Data

Impact of change to ML: role of code

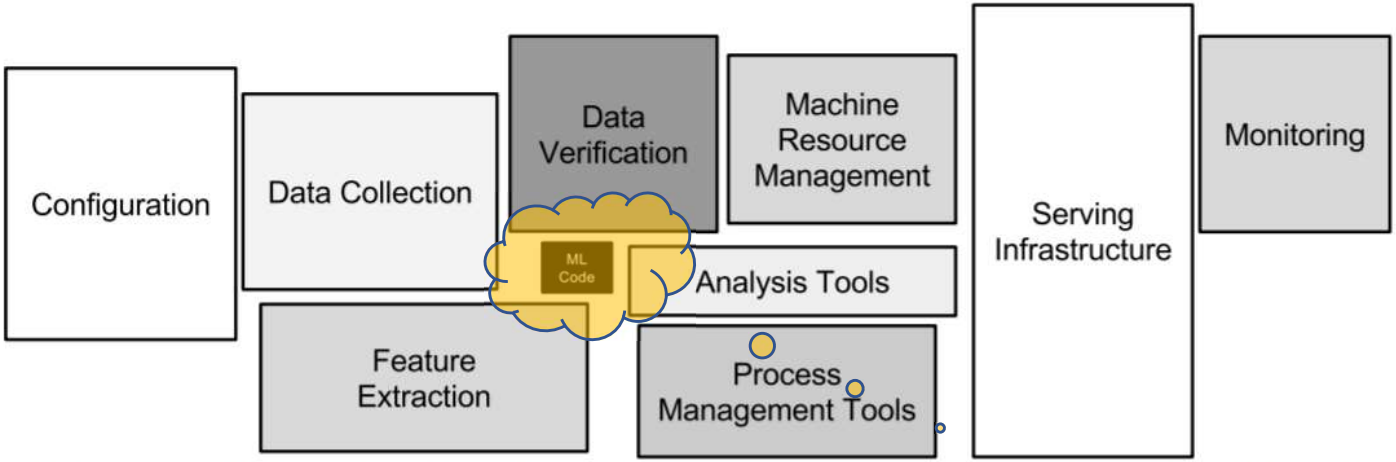
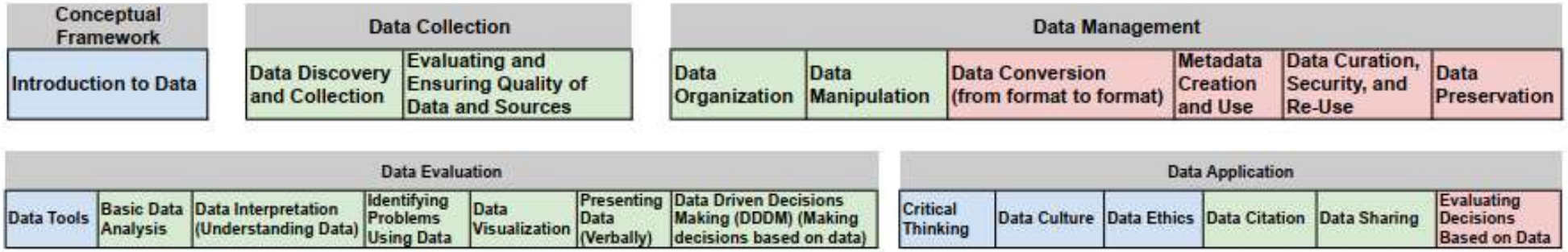


Figure 1: Only a small fraction of real-world ML systems is composed of the ML code, as shown by the small black box in the middle. The required surrounding infrastructure is vast and complex.

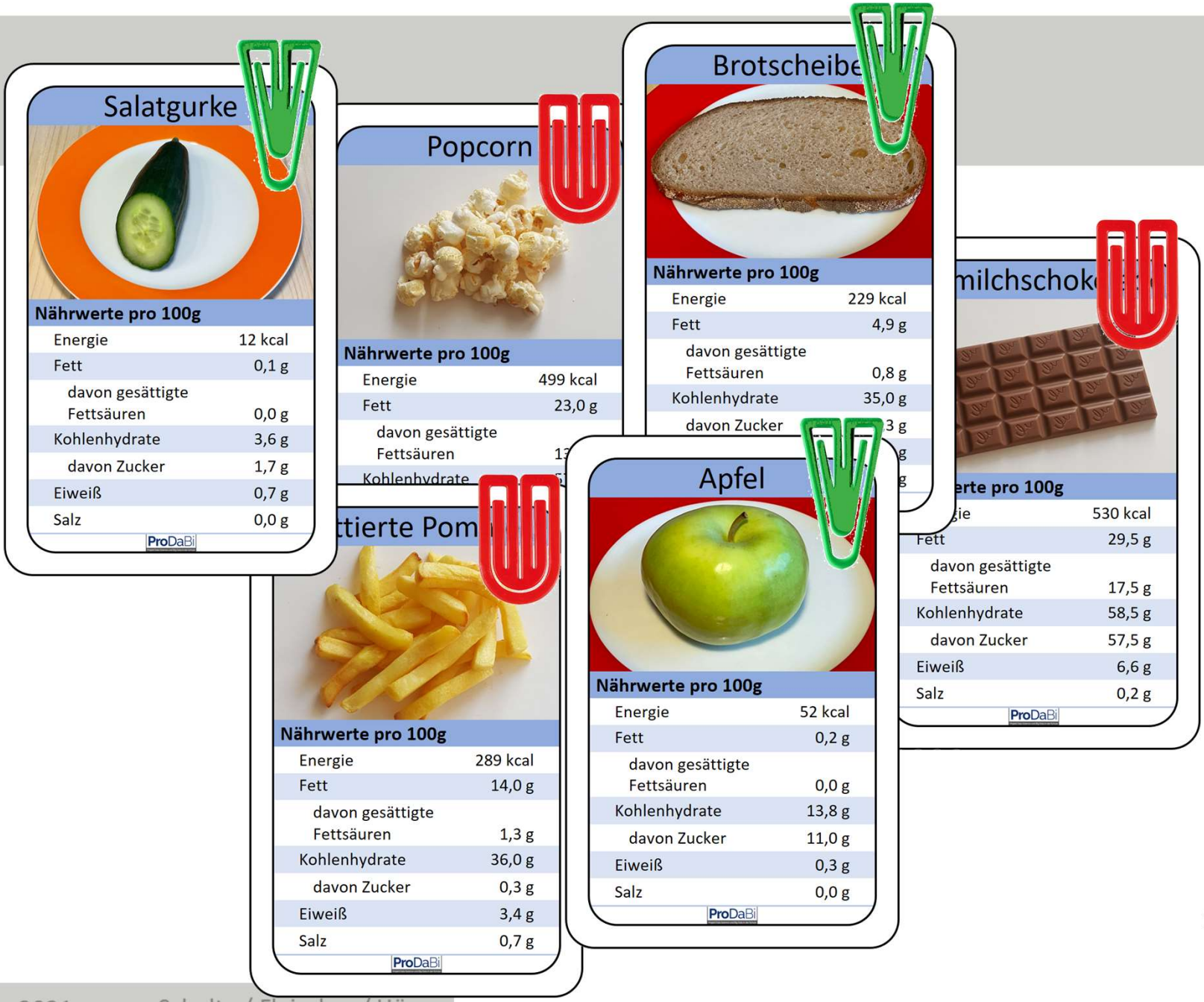
SCULLEY, D., et al., 2015. Hidden Technical Debt in Machine Learning Systems. In: *Advances in Neural Information Processing Systems* [online]. Curran Associates, Inc. 2015.

Impact of change to ML: role of data



RIDSDALE, et al., 2015. Strategies and best practices for data literacy education: knowledge synthesis report [online]. Dalhousie University p.3

Data as Model


Salatgurke
Nährwerte pro 100g
Energie 12 kcal
Fett 0,1 g
davon gesättigte Fettsäuren 0,0 g
Kohlenhydrate 3,6 g
davon Zucker 1,7 g
Eiweiß 0,7 g
Salz 0,0 g
ProDaBi
Popcorn
Nährwerte pro 100g
Energie 499 kcal
Fett 23,0 g
davon gesättigte Fettsäuren
Brotscheibe
Nährwerte pro 100g
Energie 229 kcal
Fett 4,9 g
davon gesättigte Fettsäuren 0,8 g
Kohlenhydrate 35,0 g
davon Zucker
Apfel
Nährwerte pro 100g
Energie 52 kcal
Fett 0,2 g
davon gesättigte Fettsäuren 0,0 g
Kohlenhydrate 13,8 g
davon Zucker 11,0 g
Eiweiß 0,3 g
Salz 0,0 g
ProDaBi
Nährwerte pro 100g
Energie 289 kcal
Fett 14,0 g
davon gesättigte Fettsäuren 1,3 g
Kohlenhydrate 36,0 g
davon Zucker 0,3 g
Eiweiß 3,4 g
Salz 0,7 g
ProDaBi
Nährwerte pro 100g
Energie 530 kcal
Fett 29,5 g
davon gesättigte Fettsäuren 17,5 g
Kohlenhydrate 58,5 g
davon Zucker 57,5 g
Eiweiß 6,6 g
Salz 0,2 g
ProDaBi

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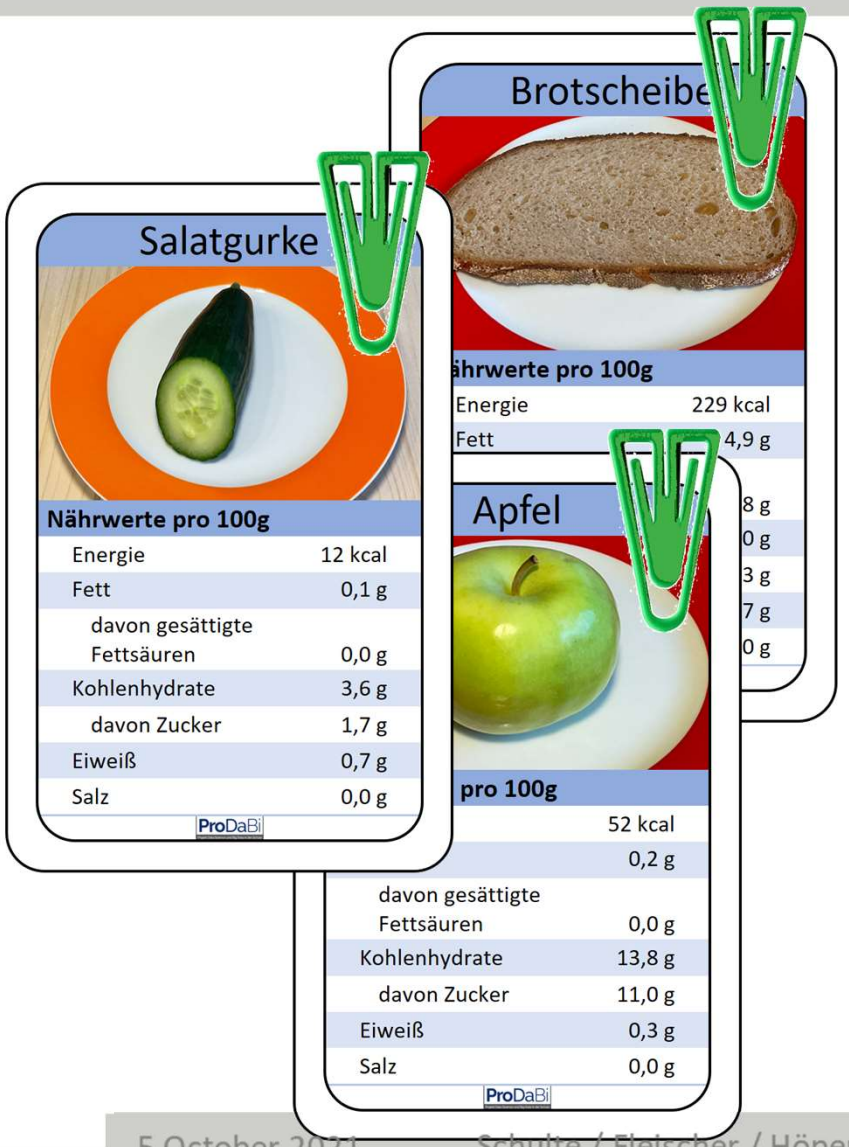
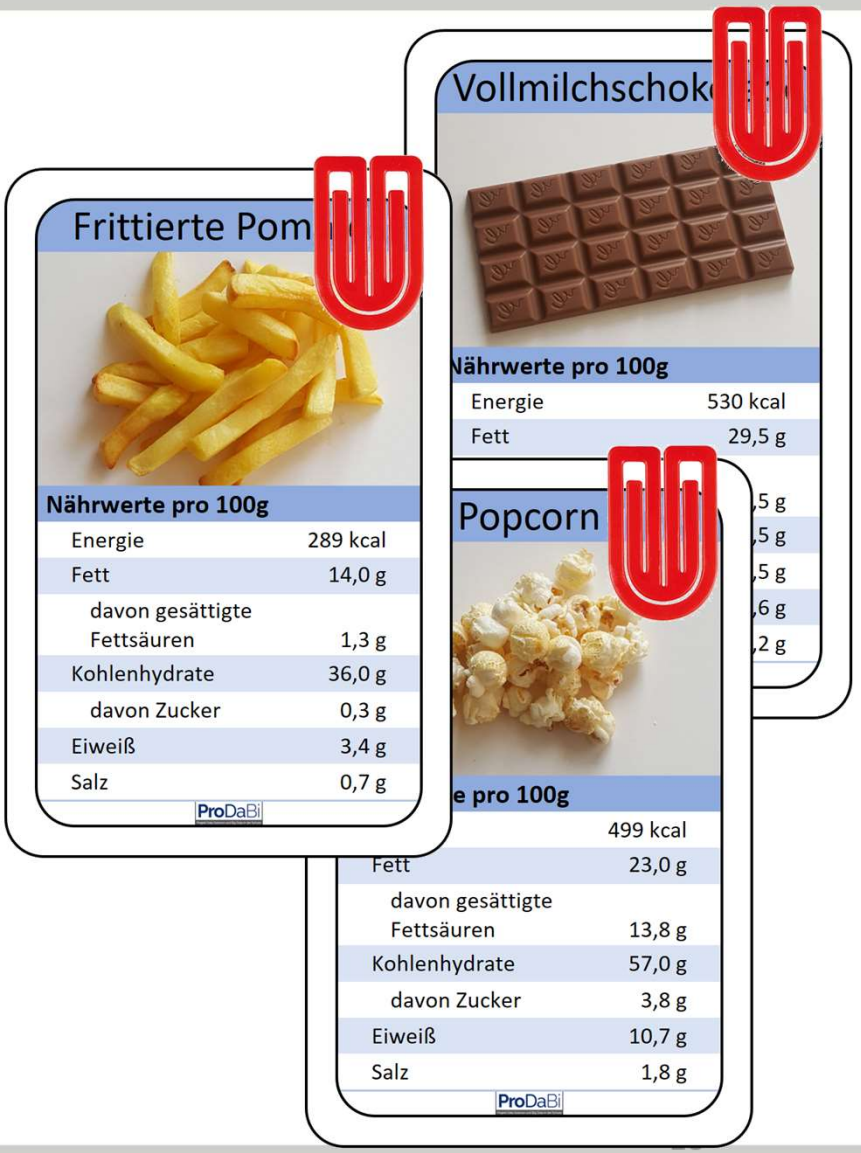
Data Split with attribute Energy

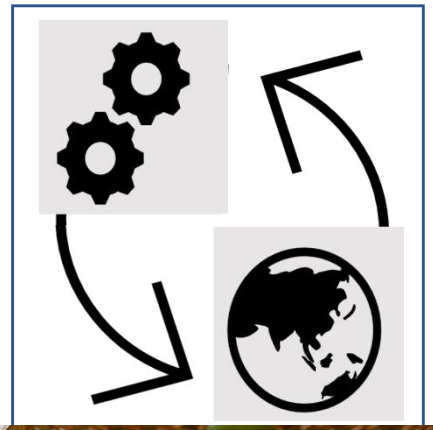


260 kcal

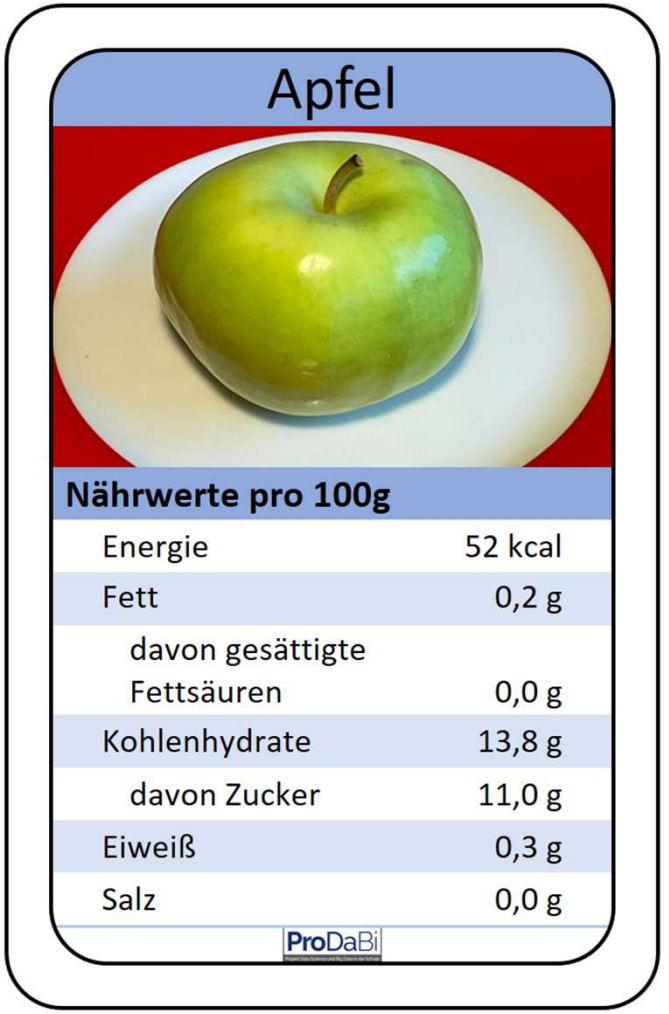


Data as model: Summary and Reflection

- What is an apple?

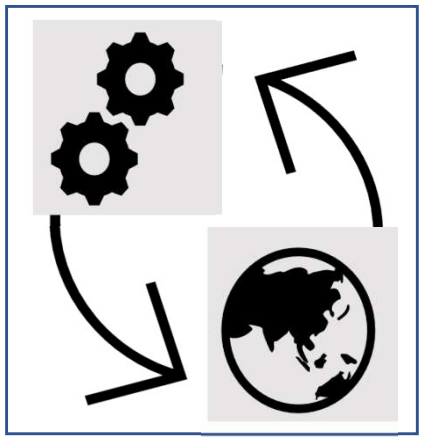


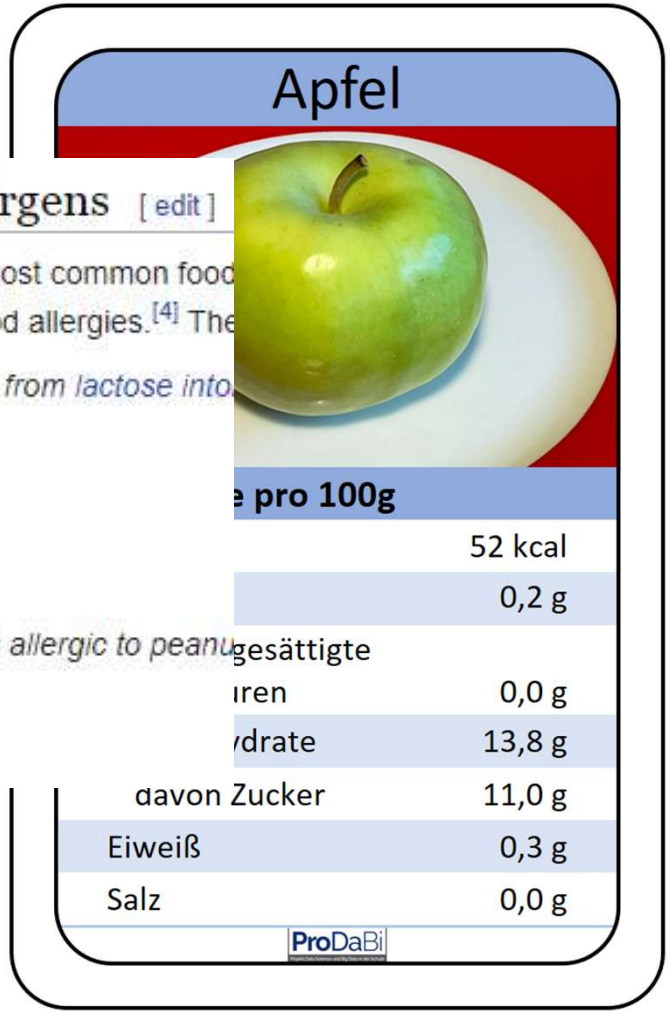
variability



Data as model: Summary and Reflection

- Why these attributes?

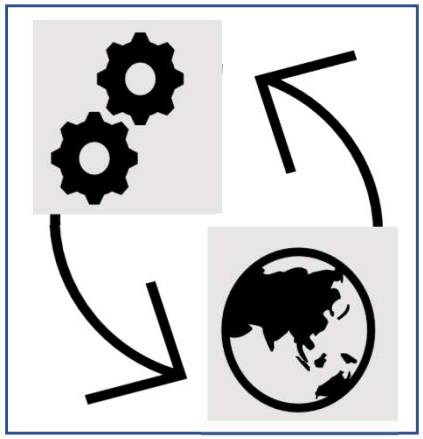




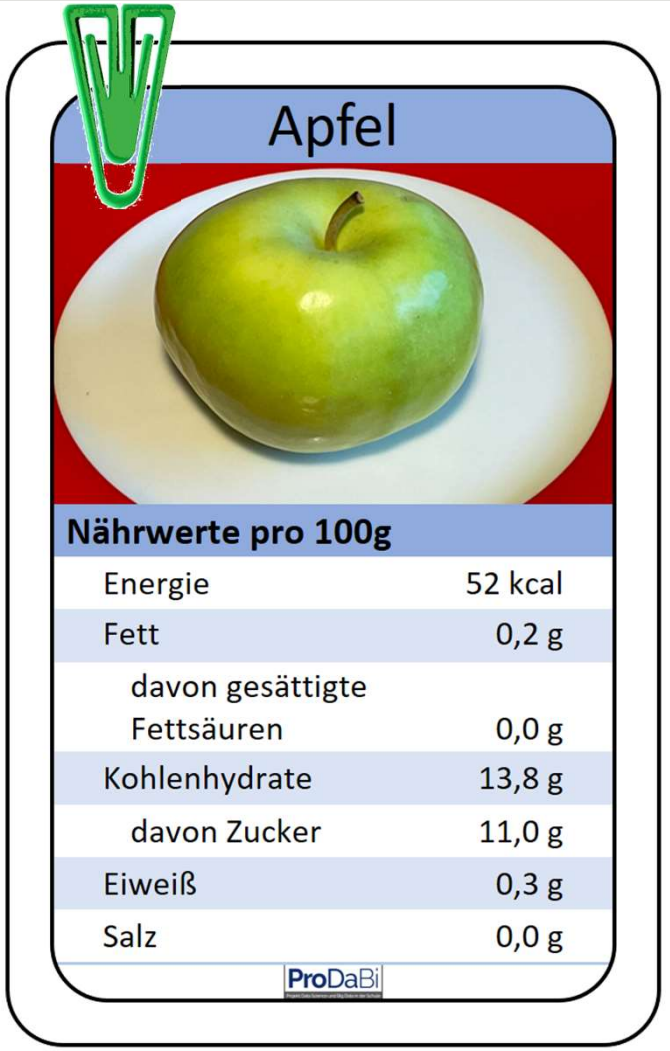
https://en.wikipedia.org/wiki/Food_Allergen_Labeling_and_Consumer_Protection_Act

Data as model: Summary and Reflection

- Why these label?



- bias in label
- proxies



Proxies: O'NEIL, Cathy, 2017. Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy. 01. London: Penguin. ISBN 978-0-14-198541-1.

Rationale

Machine Behaviour, 2019

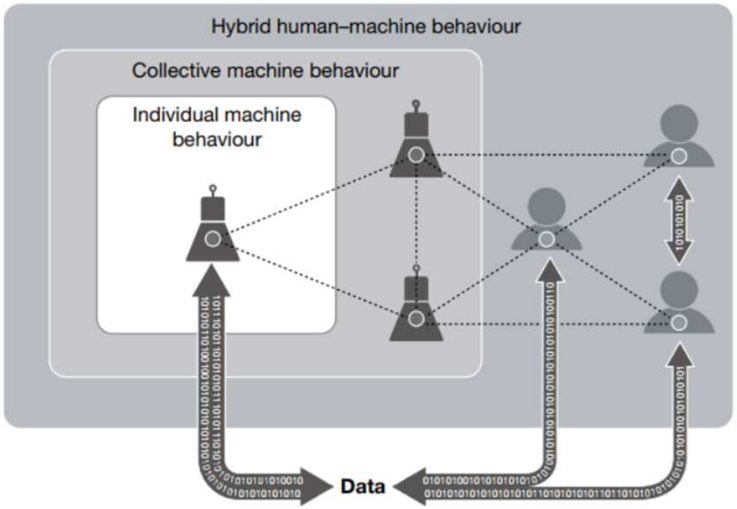


Fig. 4 | Scale of inquiry in the machine behaviour ecosystem. AI systems represent the amalgamation of humans, data and algorithms. Each of these domains influences the other in both well-understood and unknown ways. Data—filtered through algorithms created by humans—influences

Rahwan, Iyad ; Cebrian, Manuel ; Obradovich, Nick ; Bongard, Josh ; Bonnefon, Jean-François ; Breazeal, Cynthia ; Crandall, Jacob W. ; Christakis, Nicholas A. ; u. a.: Machine behaviour. In: Nature Bd. 568 (2019), Nr. 7753, S. 477–486. — tex.ids= Rahwan.2019, rahwanMachineBehaviour2019a

Computational Thinking, 2006

“Ideas, not artifacts”

1970 1980 1990 2000 2010 2020

WING, Jeanette M, 2006. Computational Thinking. *Communications of ACM*. March 2006. Vol. 49, p. 33–35. DOI 10.1145/1118178.1118215.
p. 35

Renewed interest in modelling due to ML?