AI in K-12 Education

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From Computational Thinking to AI Thinking

Computational Thinking 2.0

Table 1: Comparison of educational concerns in traditional programming education vs. education for creating ML and other data-driven models.

	CT1.0	CT 2.0
Stage 1	Formalize the problem	Collect data from the intended context
Stage 2	Design a solution	Filter and clean data. Label data.
Stage 3	Implement the solution in a stepwise program	Train a model from the available data
Stage 4	Compile and execute the program	Evaluate and use the model
ution	Weakly context-dependent	Strongly context-dependent
on	In some cases clearly works or doesn't. Can be formally proven to be either correct or incorrect (at advanced levels). Effectiveness can be proven.	Models may display higher or lower confidence. Efficiency can be established through testing. Statistically better or worse (at advanced levels).
	Black-boxed or glass-boxed cross checking of the outputs and the program code	Evaluate the model against predictions, completely black boxed
	Tracking and tracing program states and code for error.	Experimenting with data, parameters, and hyperparameters, based on trial and error
solving	Deductive	Inductive
Structure	Transparent. Visualization tools available.	Black boxed
Notional machines	Stepwise, deterministic, discrete flow of program through states (as contents of memory locations).	Parallel, possibly nondeterministic, passing data through a network
Complexity concerns	Prepare for worst case, optimize for average case	No time / space variance between passing data through a network
Portability	Tedious to make portable to different platforms.	Straightforwardly portable
Trial and error	Discouraged	Necessary
Software life cycle	Traditional, well established life cycle. Clear versioning.	More data create new "versions". Documenting is based on empiricism and reporting of training data.
Syntax and semantics	Syntactically strict, highly structured	Data can be unstructured, loose semantics

Learning ABOUT AI

Enable everyone to...

- participate in an increasingly digital world
- get involved in shaping this world
- make informed decisions about AI in society.

AI is a “new” topic for computing education (but not CS)

What?

How?

“big open question in the classroom”

What is important?

Prompt Engineering

Backpropagation

Accuracy

TensorFlow

Supervised Learning

Expert System

Alexa

Prolog

Turing Test

A*

Model

Knowledge Base

Autonomous Cars

Vector

Gradient

Logic

Chinese Room

Orange

VQ

Bayes

Perzeptron

Data Mining

Prediction

Reward and Punishment

Overfitting

SVM

Neural Network

Topic Modelling

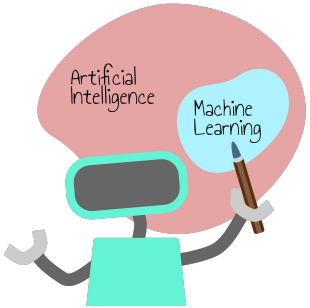
Regression

Bias

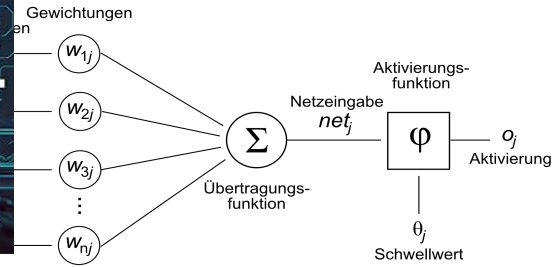
ChatGPT

k Nearest Neighbour

Label



What should everyone know about AI?



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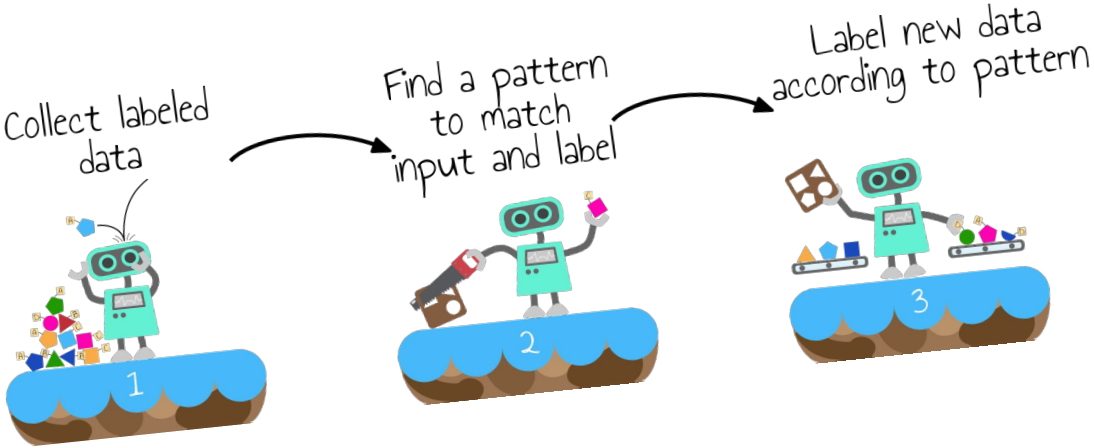
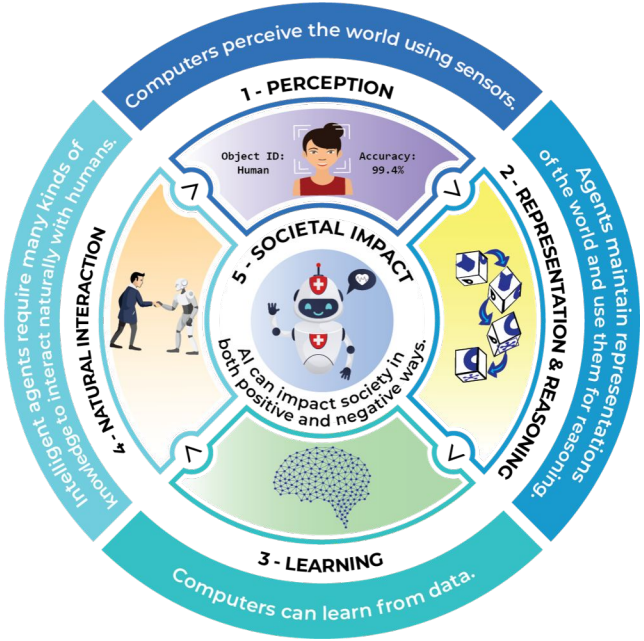
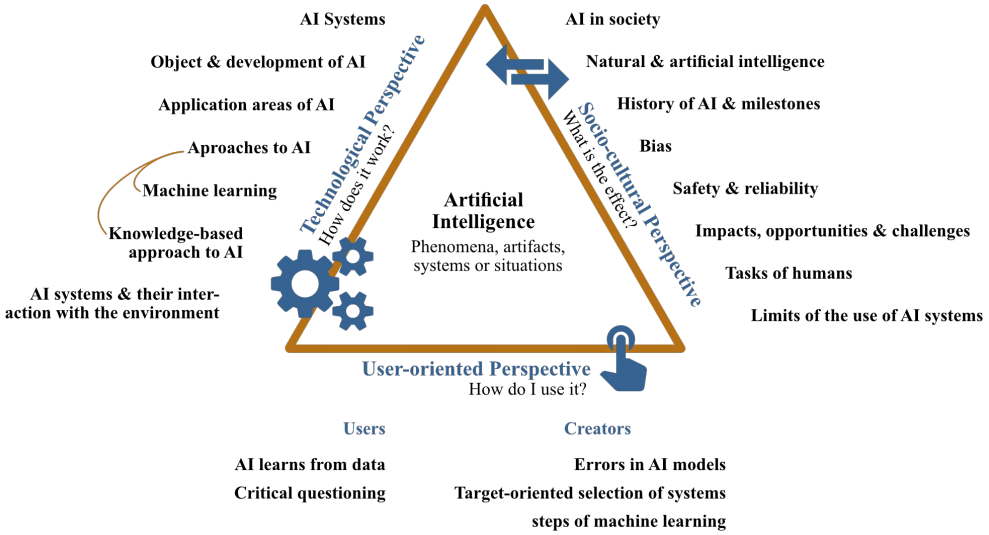
What should everyone know about AI?



Some existing approaches…



Touretzky et al., 2022



Michaeli et al., 2023

How to teach AI?

- Extremely limited experience from the classroom
- No empirical evidence

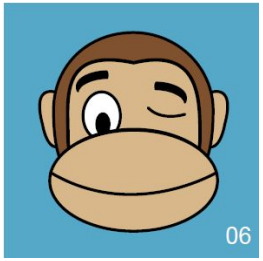
“big open question in the classroom”

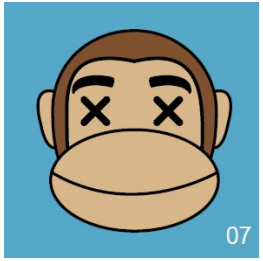
How to teach AI?

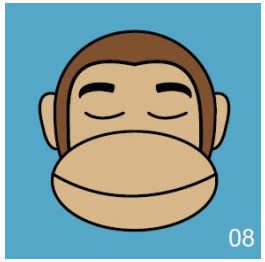
Therefore according to well-established general principles of “good” computing education

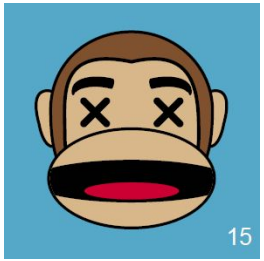
- based on ideas and concepts
- highly contextualized
- personally meaningful creative constructing

Biting

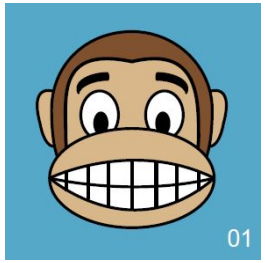


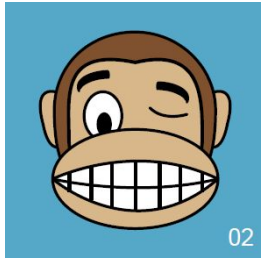


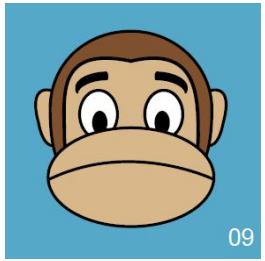


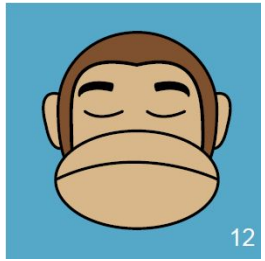


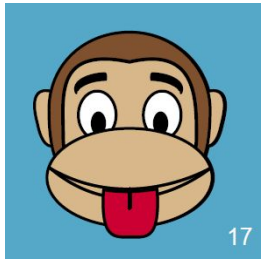
Not biting

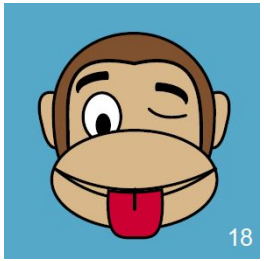






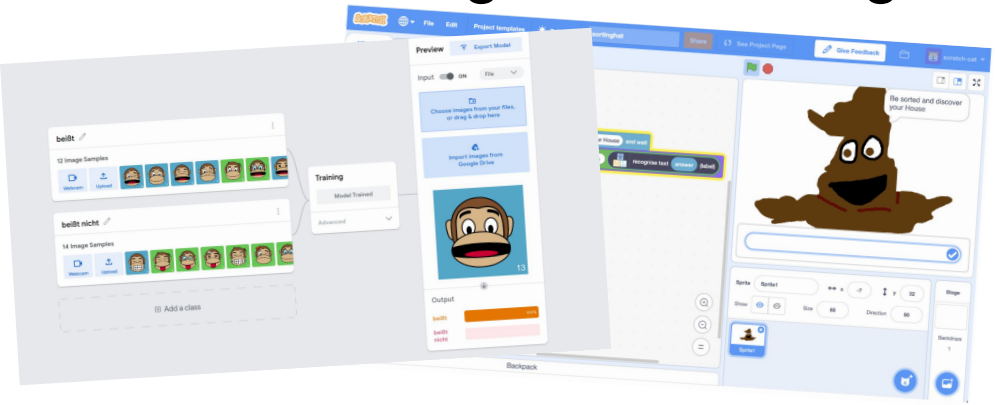




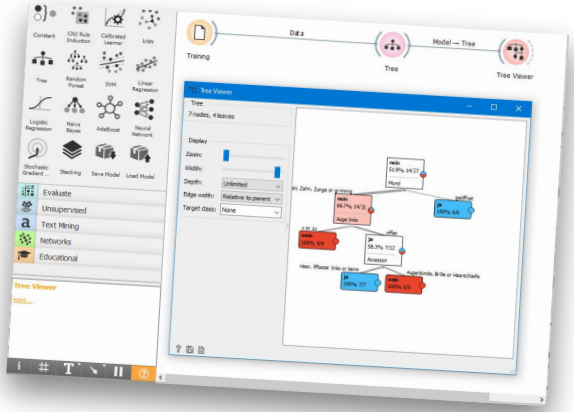


Michaeli, T., Seegerer, S., Kerber, L. & Romeike, R. (2023). Data, Trees, and Forests – Decision Tree Learning in K-12 Education. In Proceedings of the 3rd Teaching Machine Learning and Artificial Intelligence Workshop 2022, PMLR (pp. 1-5).

CS is creating, constructing and designing!



… as a blackbox



… configuring AI methods, building and testing models

… implementing AI methods on their own

In Germany…

- AI included in the revision of our national CS standards for K-12 (published “soon”)
- A lot of states already integrated AI within their curricula

Integration into teaching practice?

Bayerisches Staatsministerium für Unterricht und Kultus

Table 1: Learning Objectives in the Bavarian Curriculum on AI (year 11)

Students discuss approaches to defining the term artificial intelligence (AI), describe various basic ideas of AI methods (including machine learning) and their areas of application.
Students explain the functionality of a selected machine learning algorithm (k-nearest neighbors or decision tree learning) in general and for concrete examples.
Students analyze the influence of training data and parameters on the reliability of the results of a machine learning procedure, if necessary using a suitable tool.
Students explain the functionality of an artificial neuron (perceptron) and describe the basic structure of a neural network.
Students implement (late start: simulate) a single artificial neuron.
Students take a position on selected current possible applications of artificial intelligence and evaluate opportunities and risks for the individual and society.

- between 300 and 500 CS teachers in our area
- heterogeneous backgrounds
- little prior experience: So far, neither AI in teacher education nor in the classroom
- just over a year until teaching

Jetzinger, Baumer & Michaeli, 2024

PD for in-service teachers

Bayerisches Staatsministerium für Unterricht und Kultus

- Getting to know each other
- Playful beginning and overview
- Appetite for more

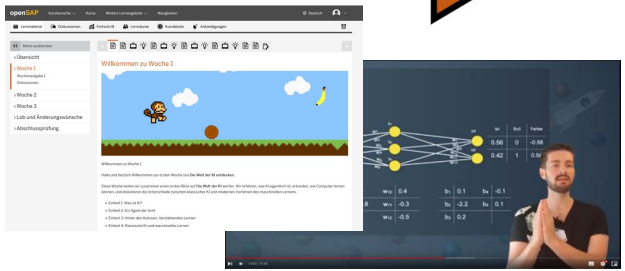
- Advanced content knowledge
- Practical implementation in the classroom

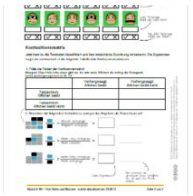
Attendance day 1
Introduction
3h

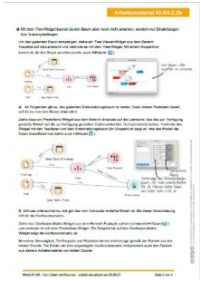
MOOC (Massive Open Online Course)
„Exploring the world of AI“
Approx. 10h (in 3-6 weeks)

Attendance day 2

Workshops
6h



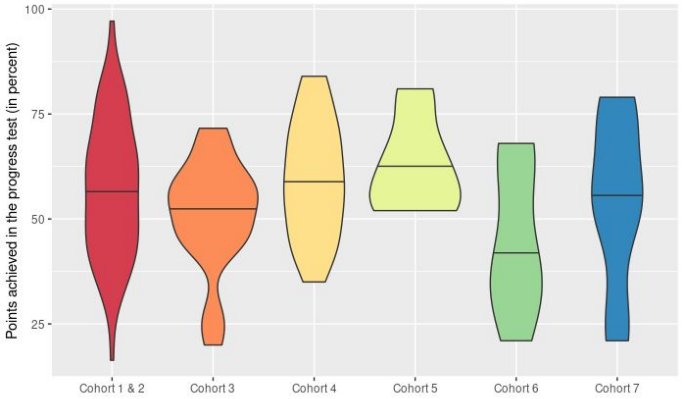




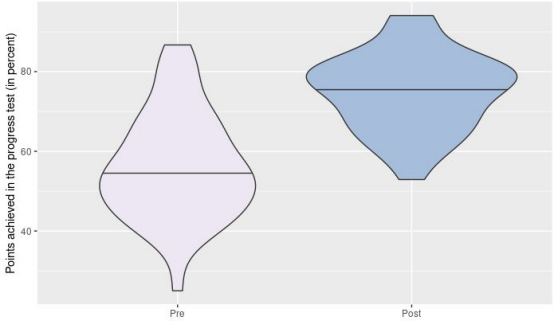
Jetzinger, Baumer & Michaeli, 2024

PD for in-service teachers

Evaluating with a “progress test”



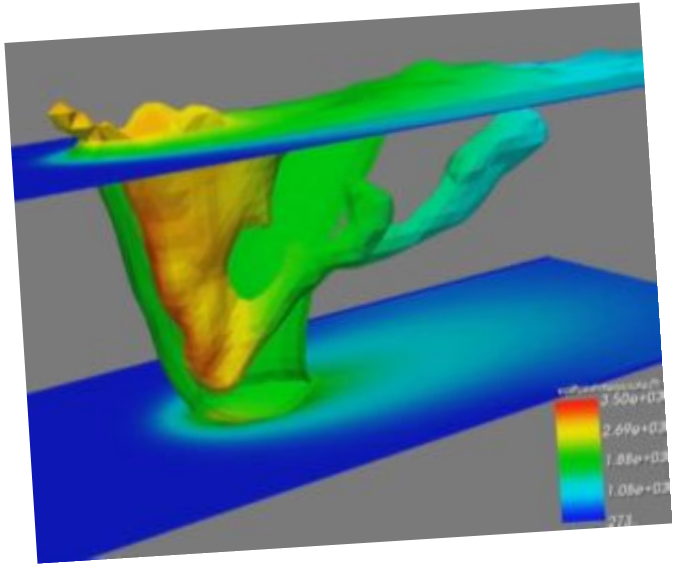
Pre for different cohorts

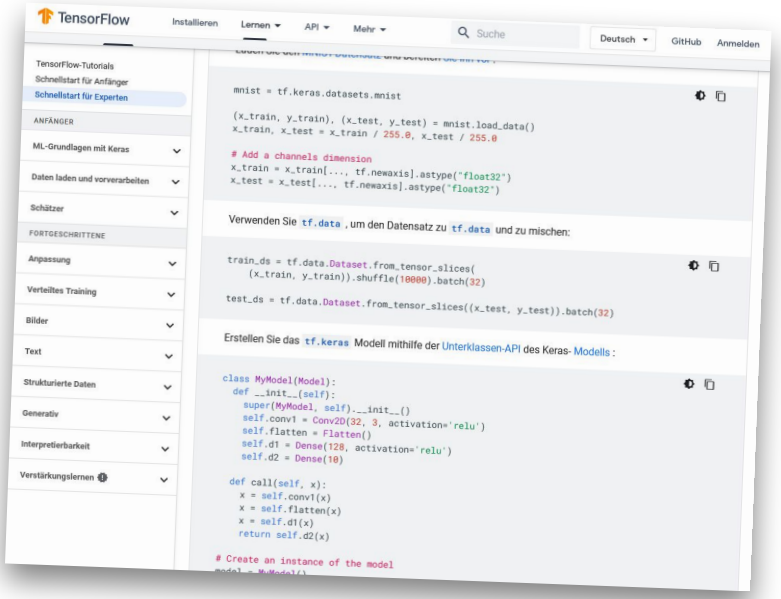


Pre-post

Jetzinger, Baumer & Michaeli, 2024

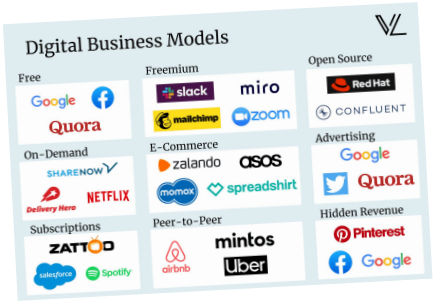
Digital Transformation and Science



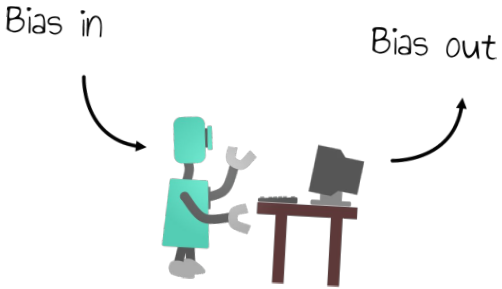


Simulations and data analysis as the 3rd and 4th pillars of science

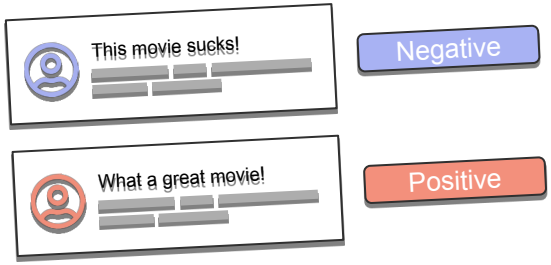
AI as Content and Method…



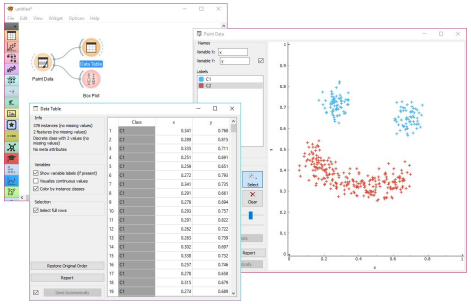
digital business models



ethics and algorithms



text document analysis
in the social sciences



analyzing measured data in
the nat. sciences

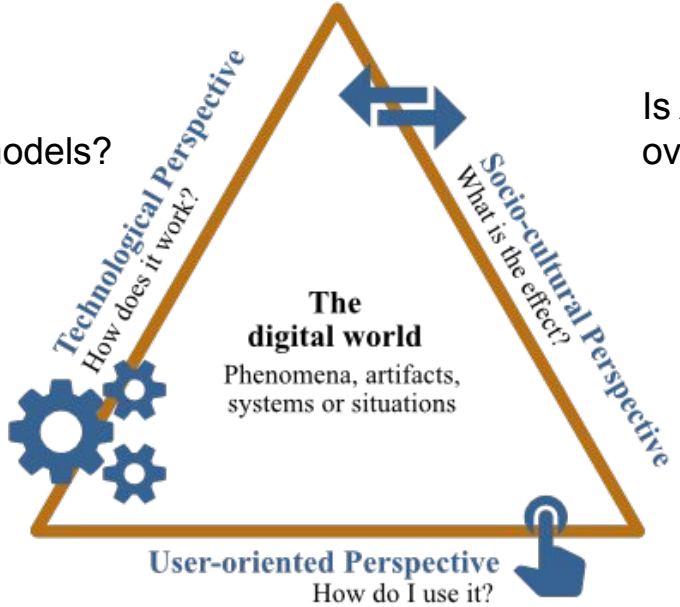
Learning & teaching WITH AI requires learning ABOUT AI!

What is a bias in the data?

What are ML models?

What is the difference between correlation and causation?

How were the data selected and prepared?



Is AI taking over my job?

The use of which data is ethically questionable?

Where could I profitably use AI in my teaching?

How do I interpret the results for an appropriate intervention?

Thank you for your attention!