

# Embodied approaches to teaching machine learning concepts and practices

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# AI literacy in K-12 education (How I work with it)

Designing non-programming interfaces  
(and activities) that make machine learning  
more graspable and explorable.

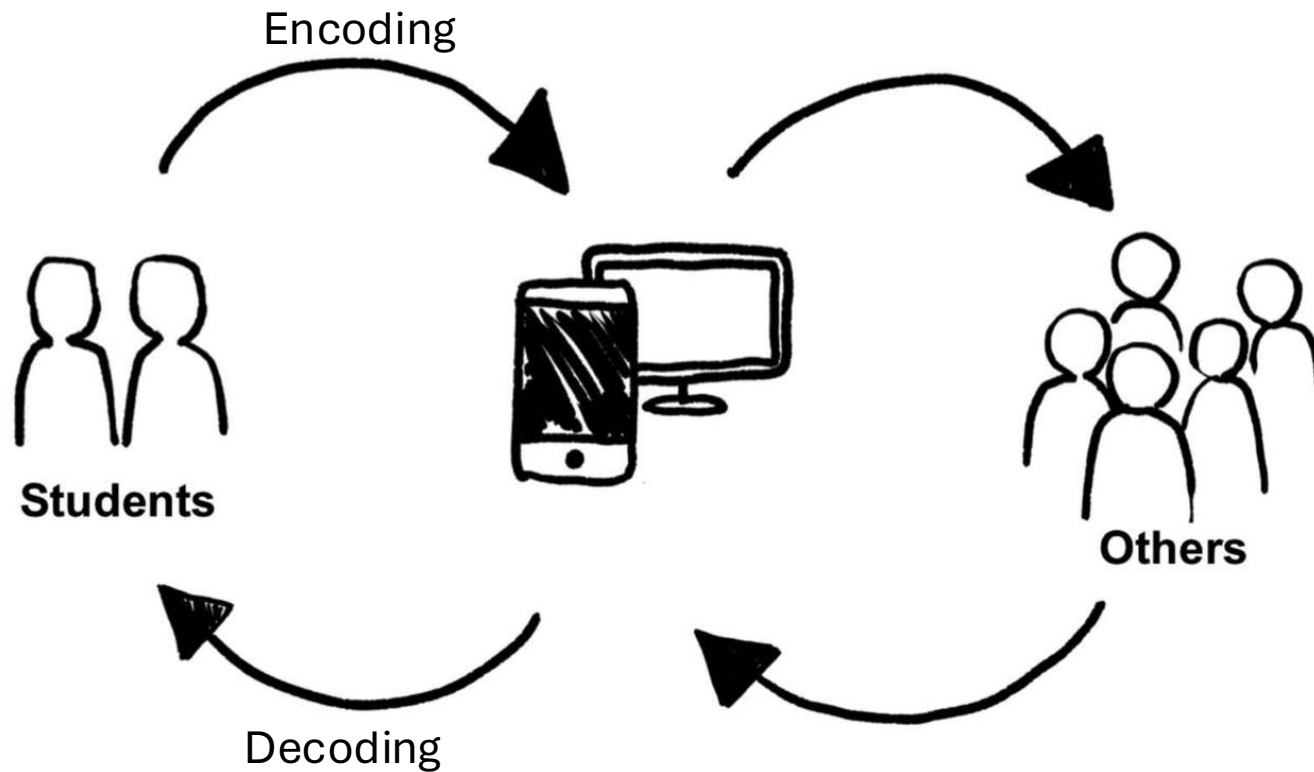
Integrating machine learning tools and  
methods into classroom practices and  
elementary and high school subjects.

Disseminating new ways to engage with  
machine learning technologies in  
classrooms.

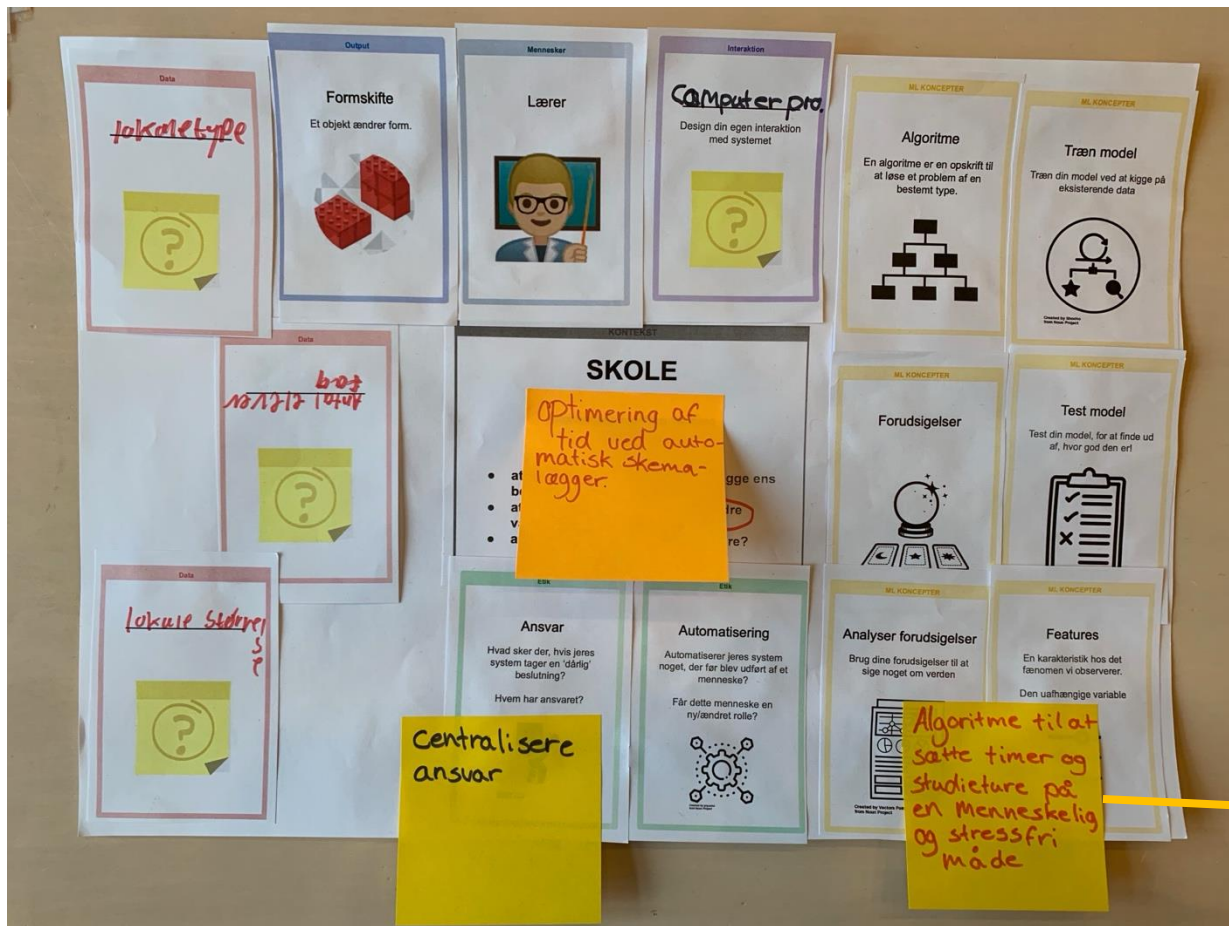




# Computational empowerment - Sustaining students' (and teachers') agency in an increasingly *digitized* and *computationalized* world.



# Machine learning ethics cards workshop



*“An algorithm to plan lessons and study trips in a humane and stress-free way”*





1: HVAD BESKRIVER DATAEN?

What does the data describe

2: HVILKEN DATA SKAL MODELLEN TRÆNES I (AT KUNNE FORUDSIGE)?

What data should the model be trained to predict?

3: HVILKE DATA INPUT SKAL BRUGES TIL AT LAVE FORUDSIGELSEN?

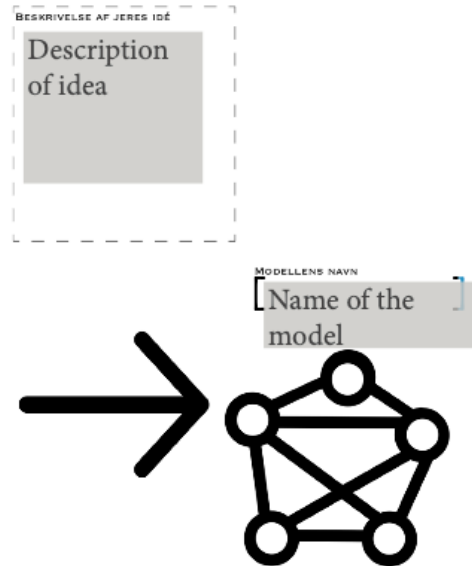
What data input is required to make the prediction?

DATA INPUT

Data input

DATA INPUT

Data input



Machine Learning icon by Agni from the Noun Project

Hasle fodboldklub

ANMELD

!

Beskrivelse

Ratings

Hasle fodboldklub

☆☆☆☆☆

- Begrundelse 1
- Begrundelse 2
- Begrundelse 3
- Begrundelse 4

DINE GRUPPER

Hasle fodbold

Sportklub

TV-klub

Basket



# Scaffolding critical reflection on the ethics of machine learning

*“The more lonely they are, the more motivated they become to get better recommendations”* – Student designing an app to help lonely peers

Coupling ethics to technology and implementation – being constrained by the technology

Engaging with ethical dilemmas through design decisions and hands-on activities

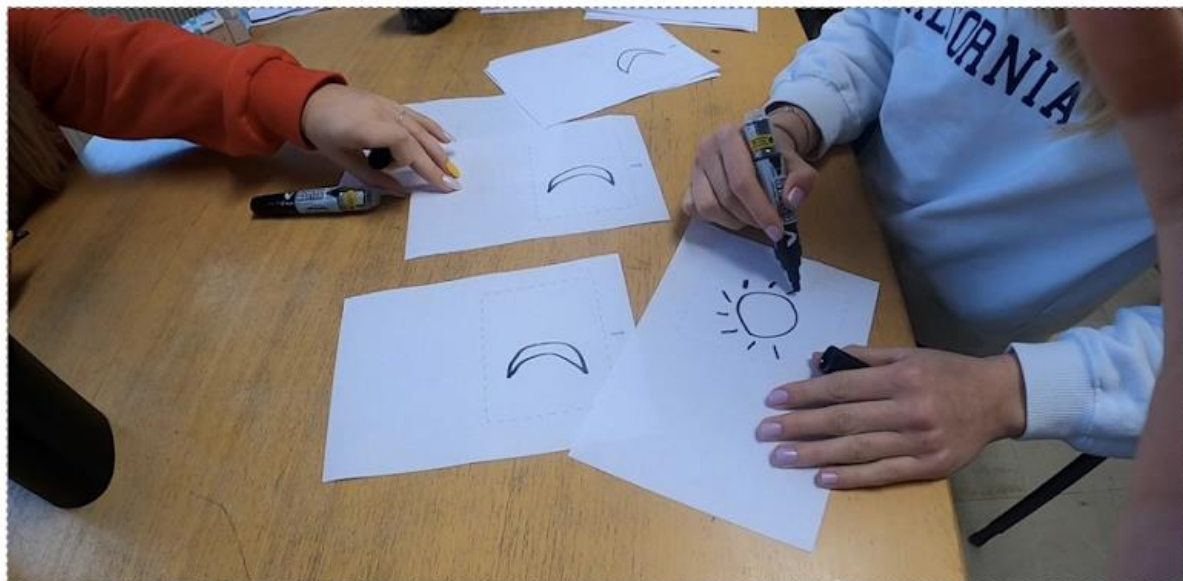
Enacting Machine learning  
practices in the classroom



# Machine learning machine



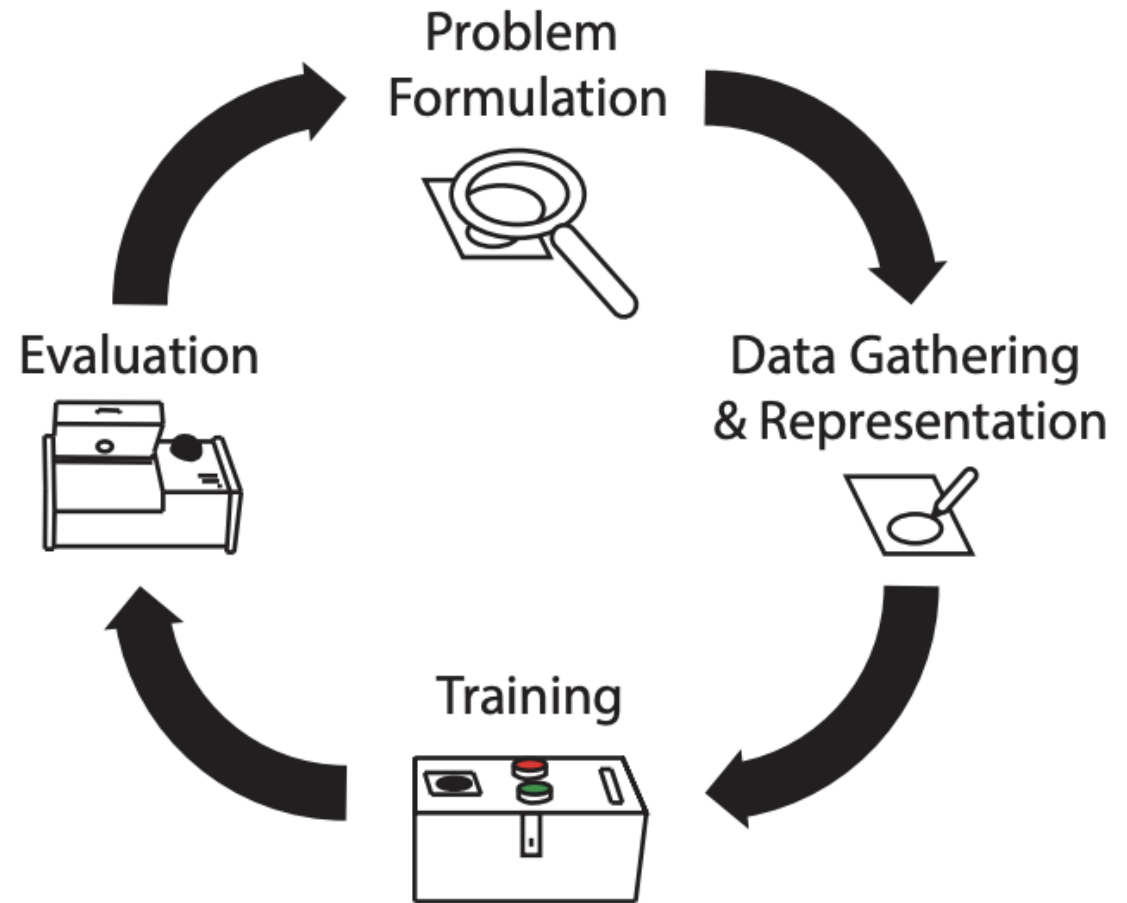
[Kaspersen et al., The Machine Learning Machine: A Tangible User Interface for Teaching Machine Learning, TEI 2021]





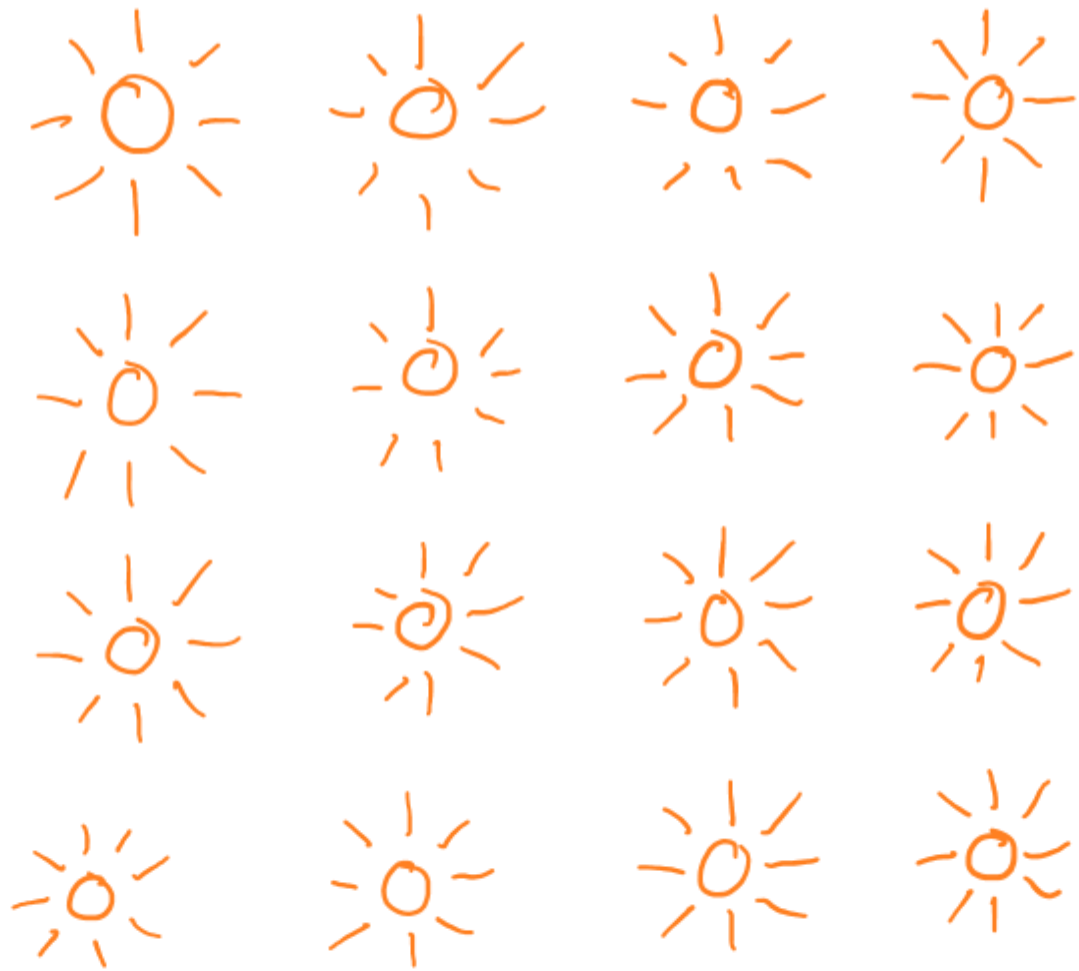
# Design rationale

- Mystical boxes in the physical classroom
- Low floor
- Experiment and iterate to explore the boxes functionality
- Powerfull tools → slow interaction

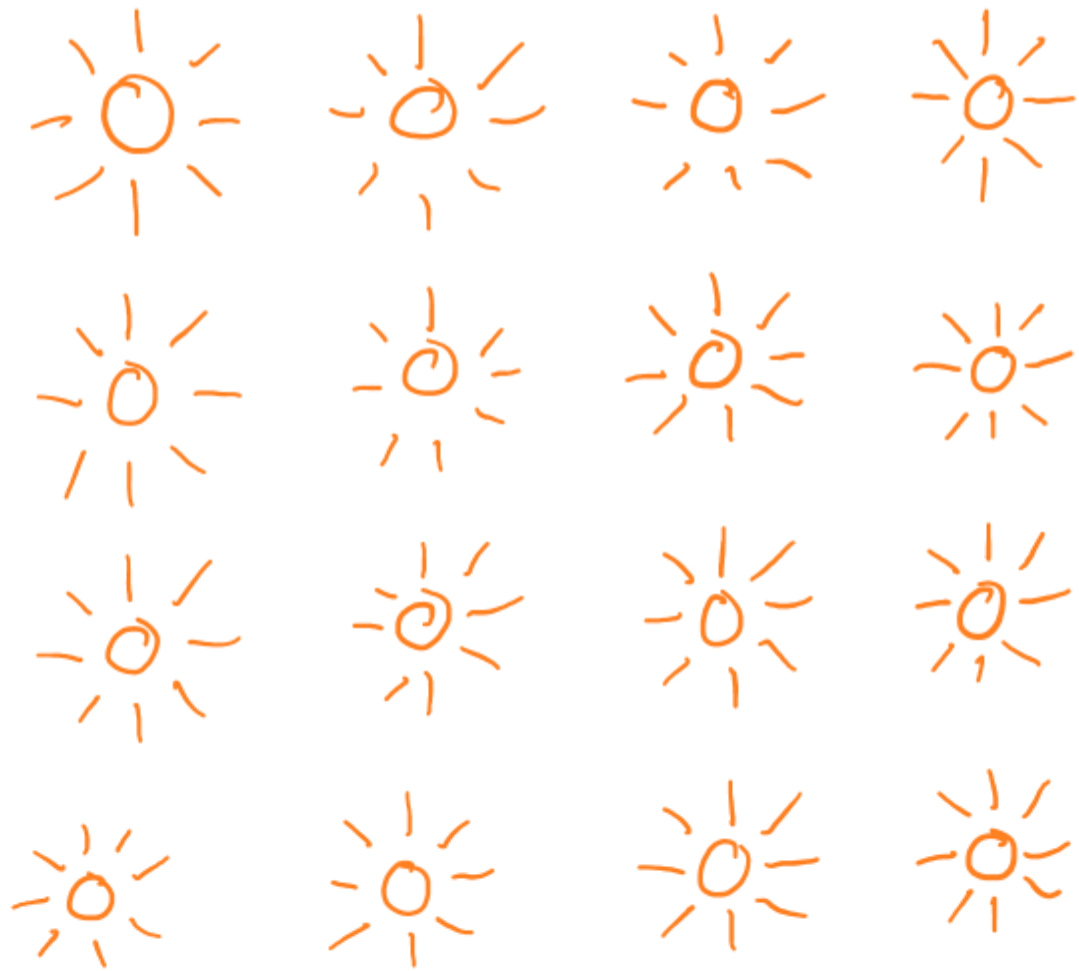




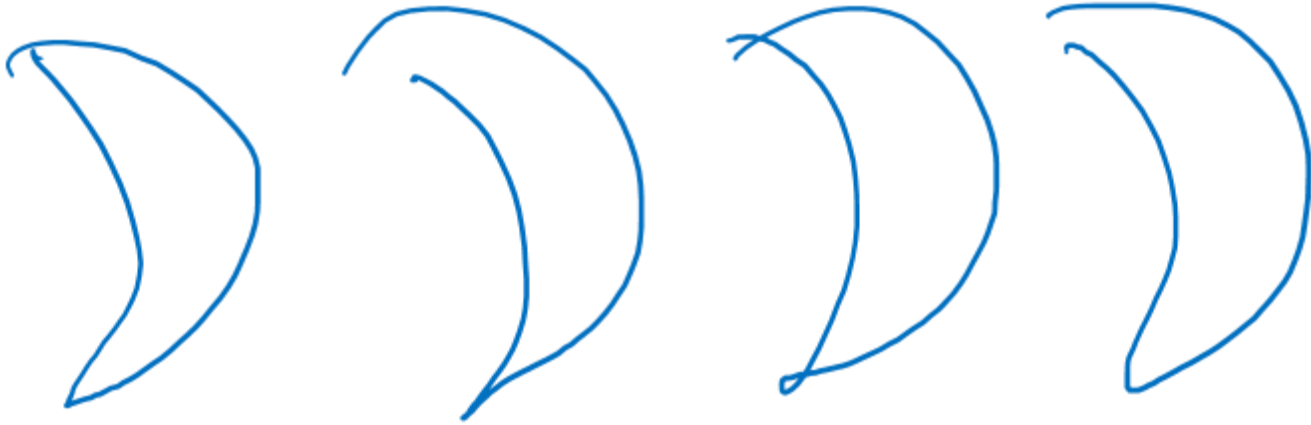
# Unintended Biases



# Unintended Biases

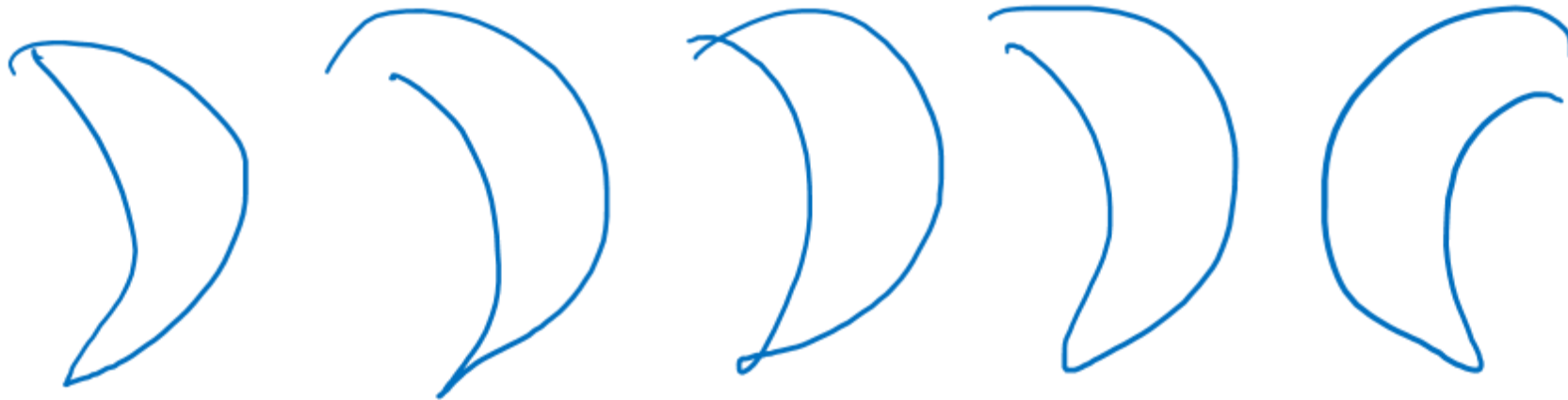


# Data Representativeness





# Data Representativeness



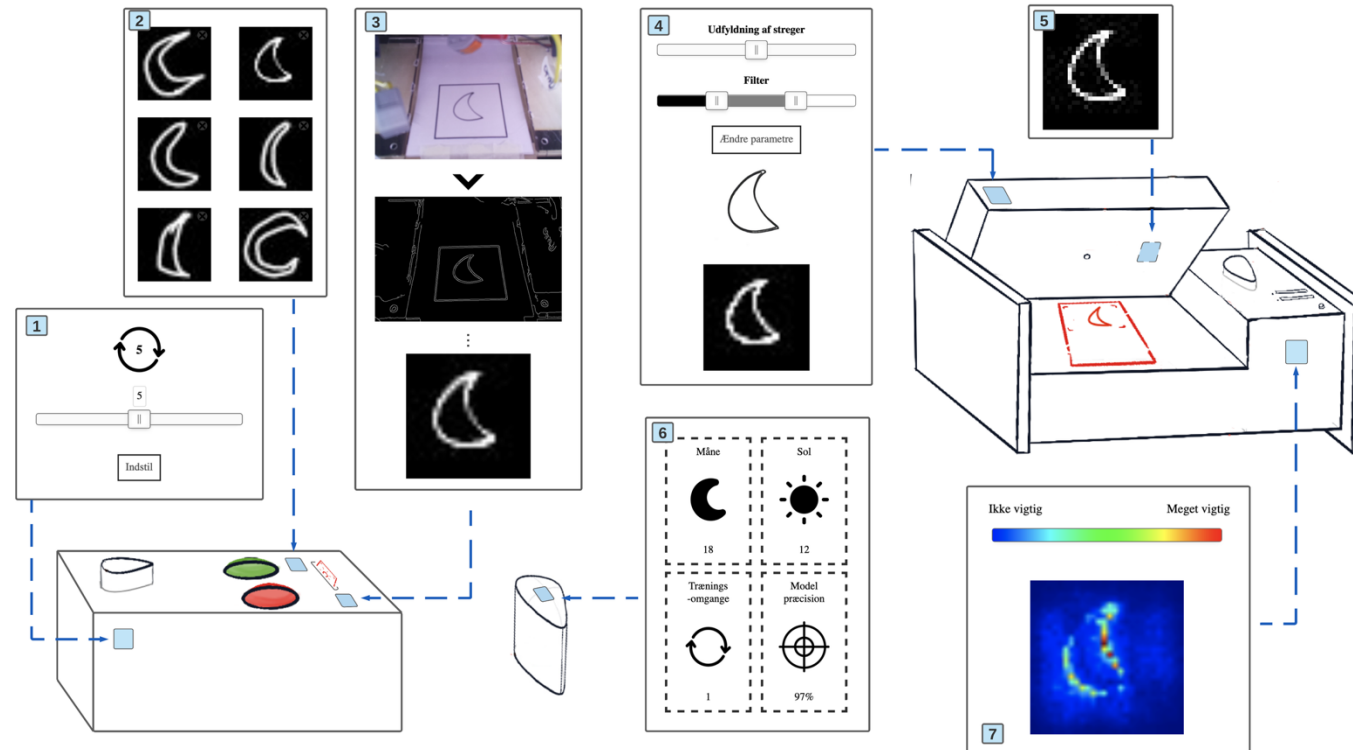
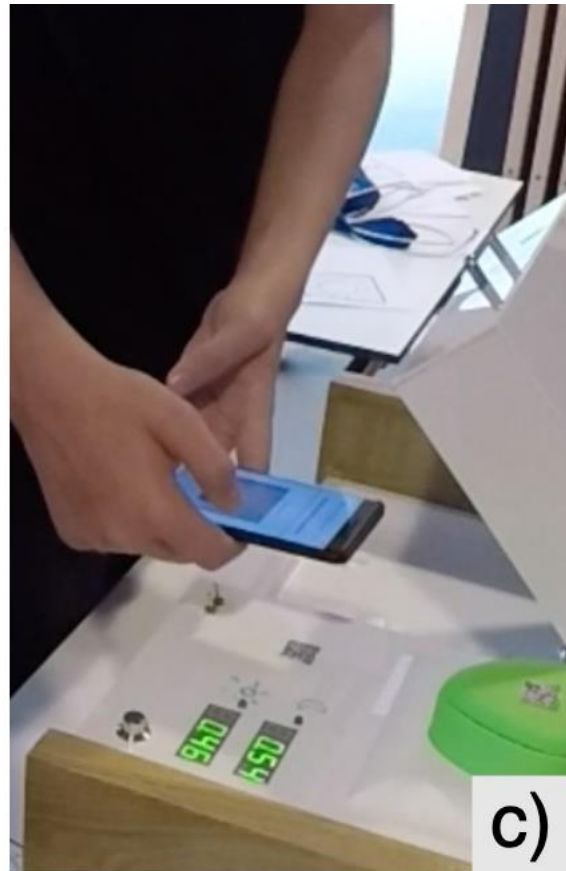
# Limitations

Students found it difficult to relate these experiences to the ML systems they meet in their own lives

Became a *‘dance around black boxes’*



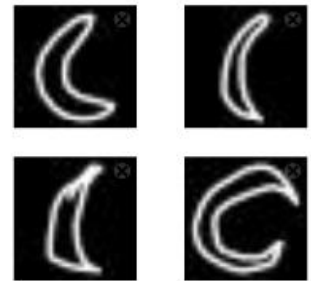
# Opening the black box



Concrete



Iconic



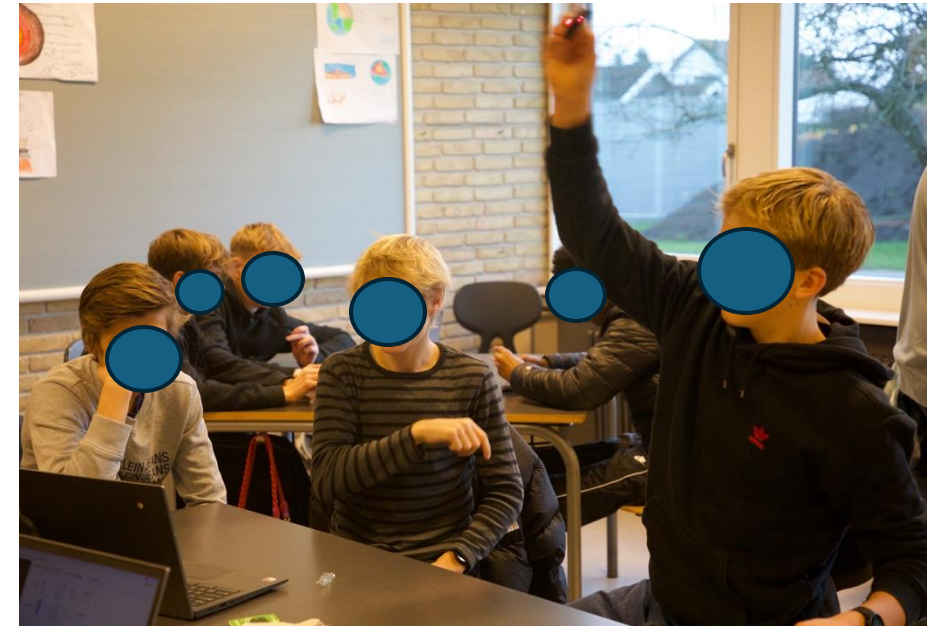
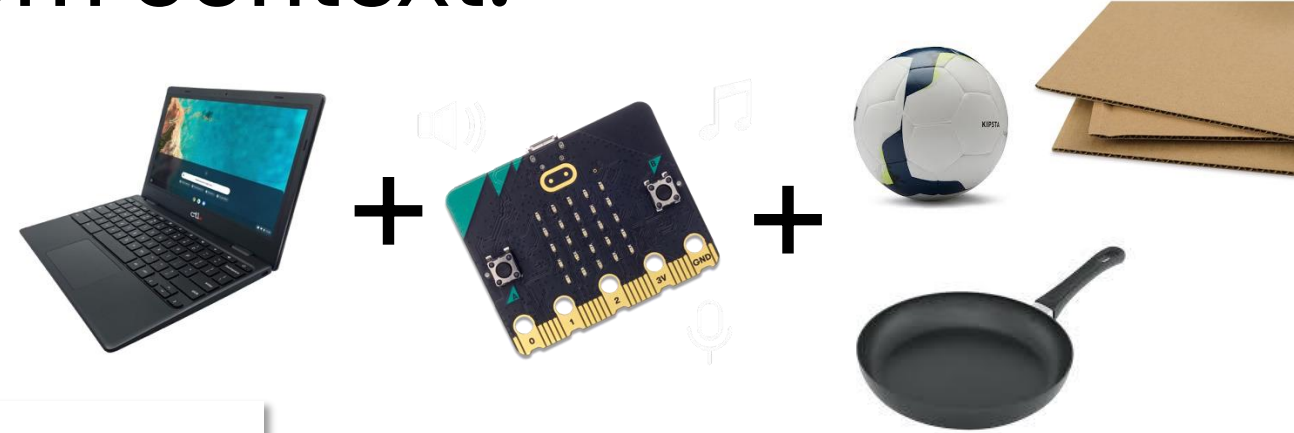
Abstract

190	163	169	184	188	185	162	152
191	174	160	117	141	179	160	161
188	181	110	39	88	165	180	178
188	172	68	25	34	119	177	164
184	169	74	32	36	131	179	127
181	162	122	67	77	162	194	152
175	160	167	138	138	181	184	180
171	158	173	168	183	194	174	191

[Bilstrup et al., The best of both worlds: Designing a tiered hybrid interface for teaching machine learning in K-9 education, NordiCHI 2022]

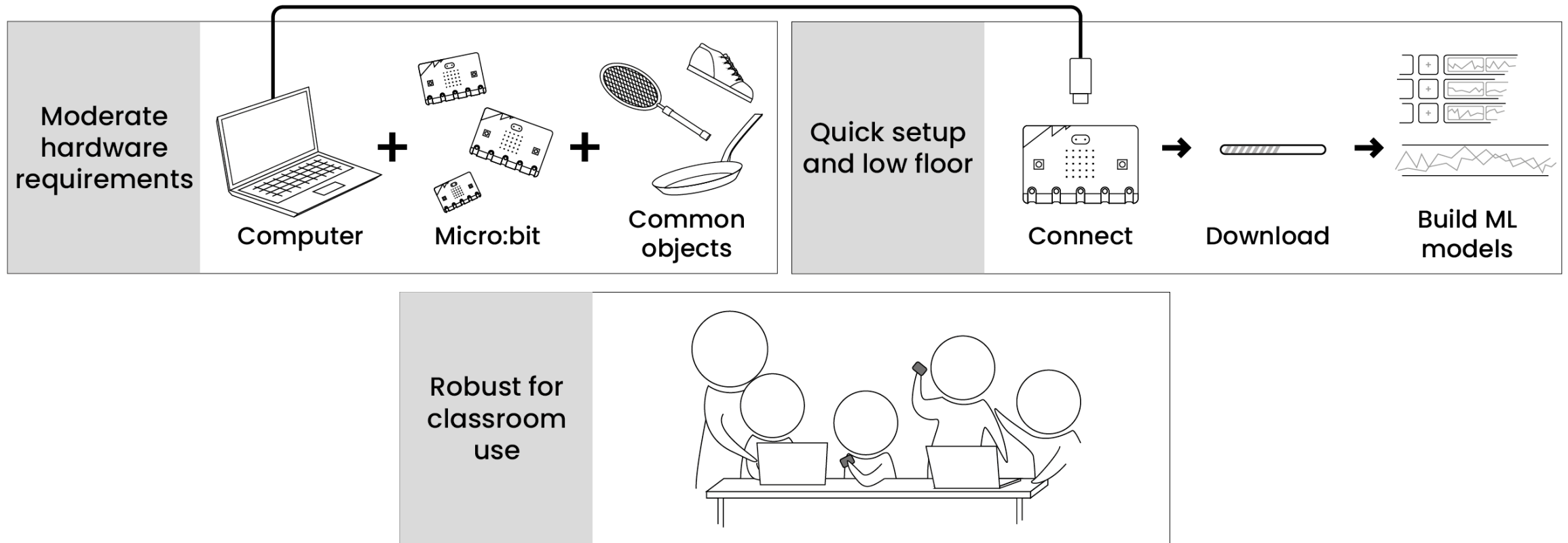


# Design for the classroom context: [ml-machine.org/](https://ml-machine.org/)



[Bilstrup et al., Opportunities and Challenges of Teaching Machine Learning as a Design Material with the micro:bit, NordiCHI 2022]

# Design for the classroom context: [ml-machine.org/](https://ml-machine.org/)



[Bilstrup et al., The ML-Machine Toolkit: Empowering Teachers and Education Professionals to Explore Embodied Approaches to Teaching Machine Learning, DIS 2025]

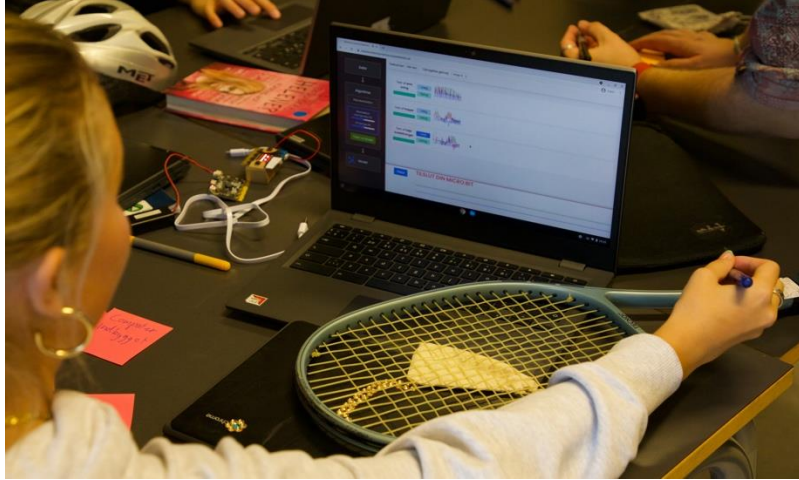
# Demo

[ml-machine.org/](https://ml-machine.org/)

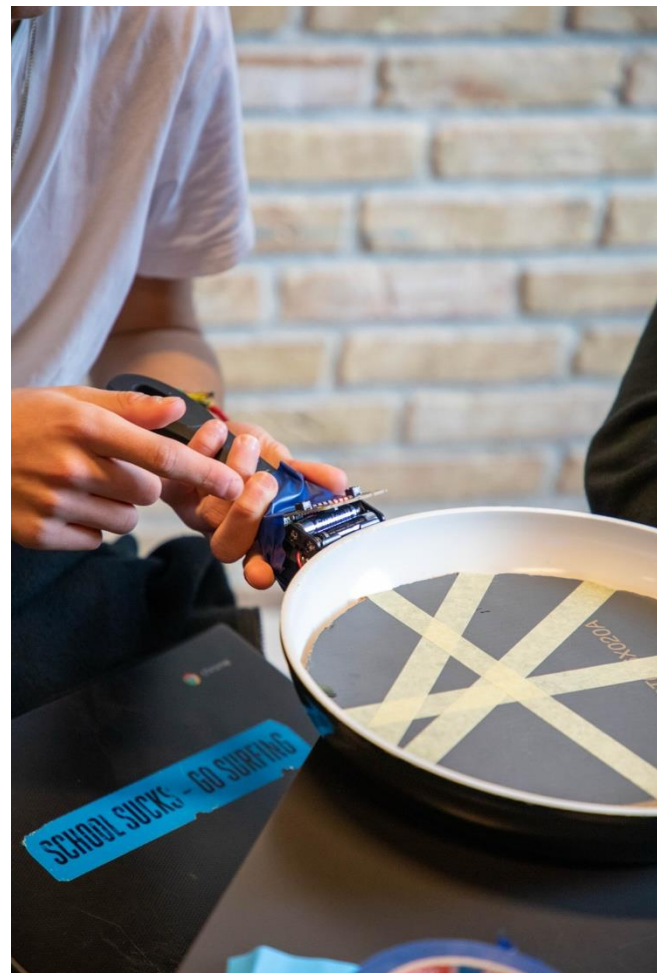


# Machine learning as a design material

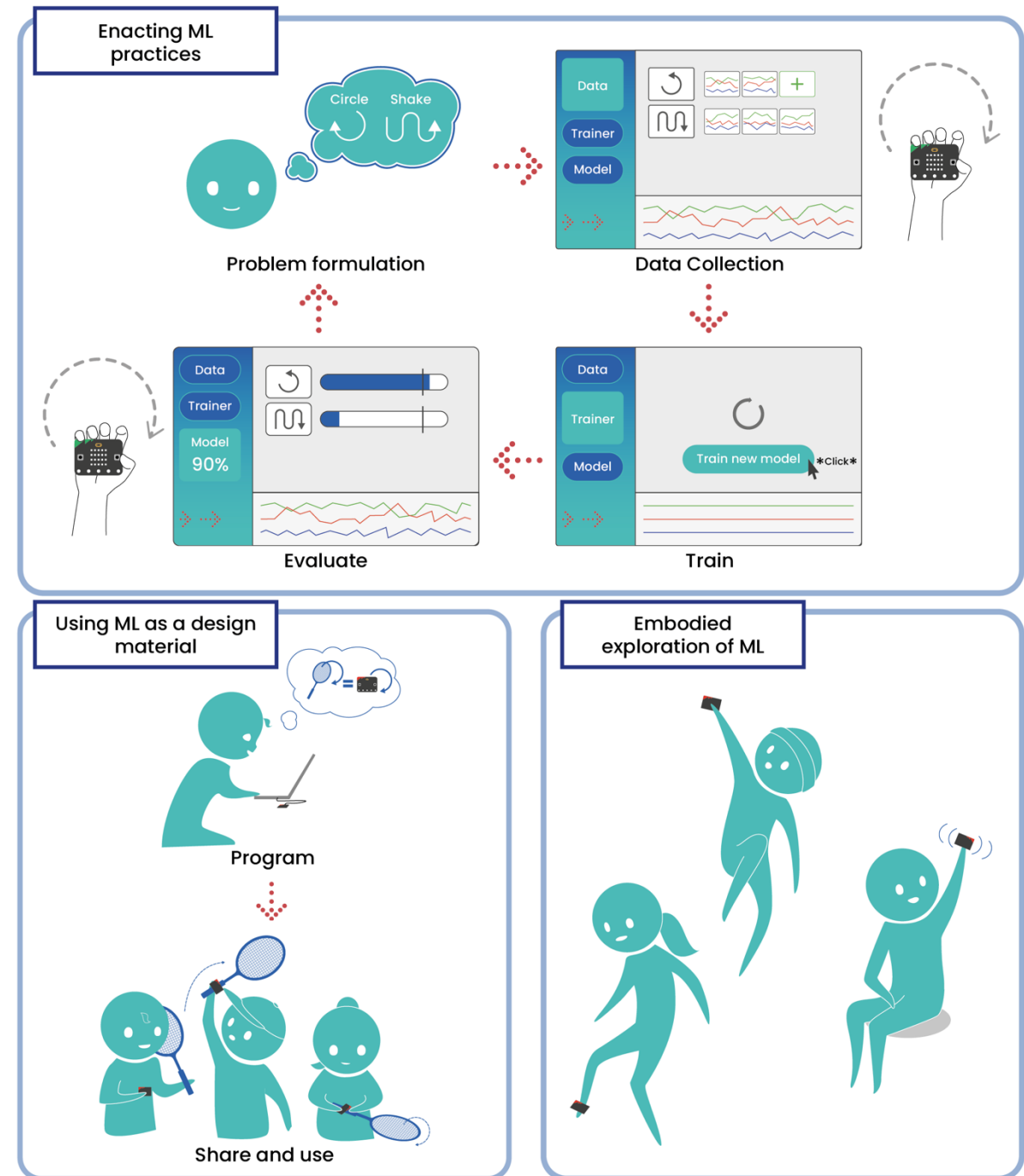
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# Learning about machine learning through embodied interaction



# Working with multiple representations and abstractions



Finding patterns in accelerometer data

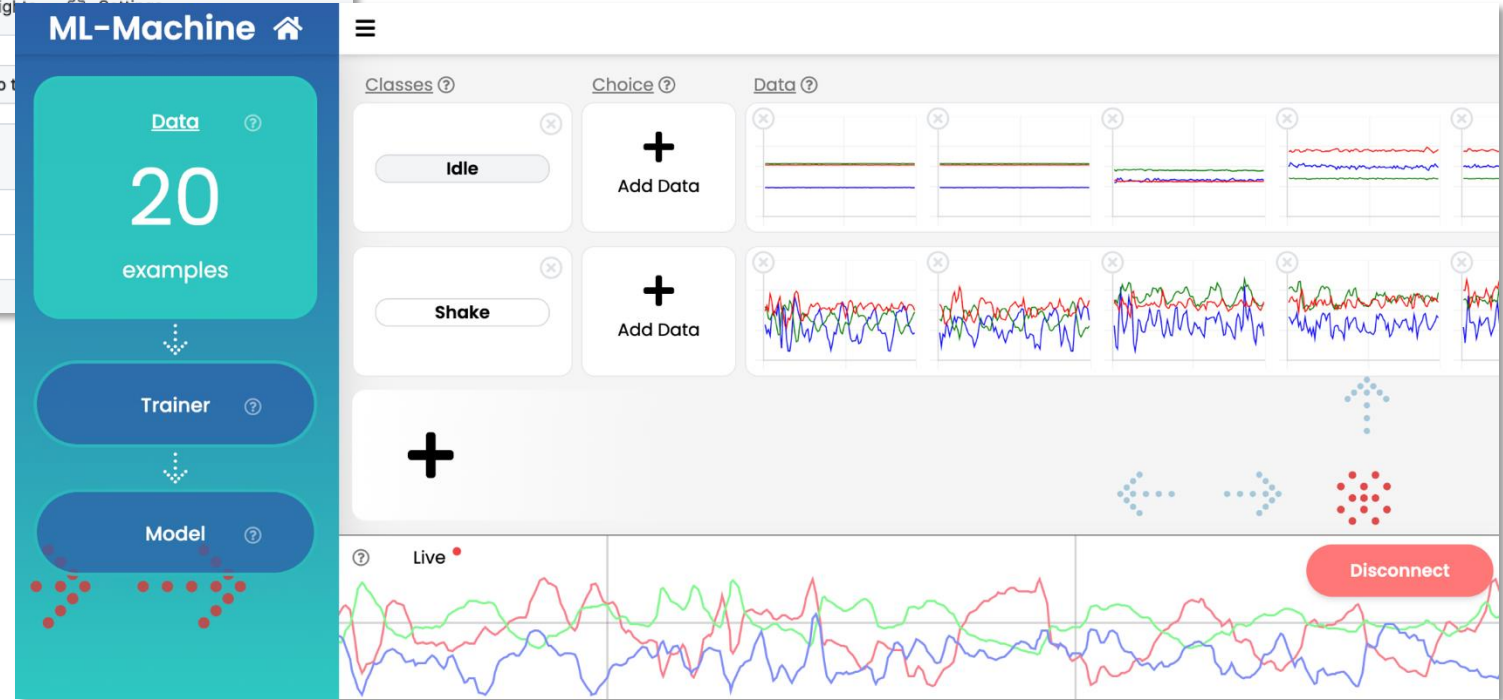
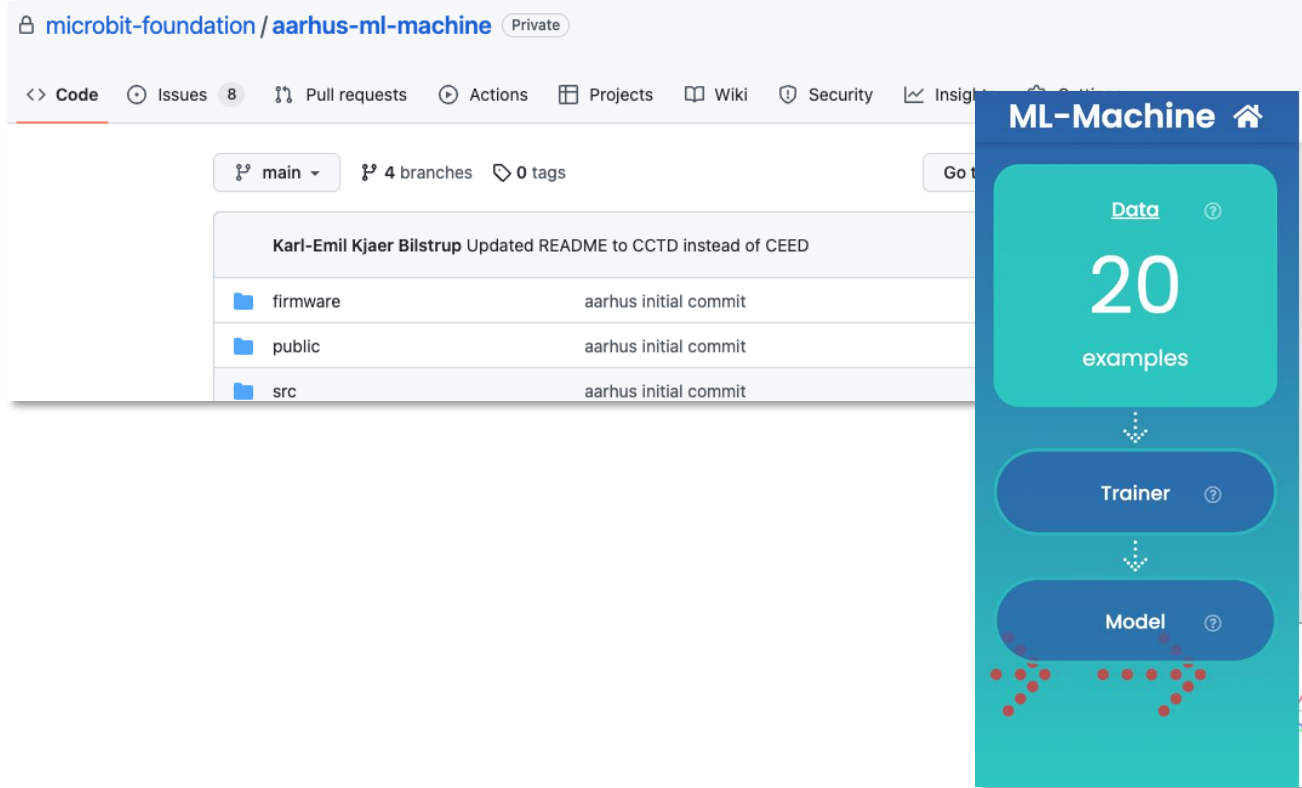


Train ML model to recognize bodily activity



Redesign a physical artefact with ML





[ml-machine.org/](https://ml-machine.org/)

[math.ml-machine.org/](https://math.ml-machine.org/) (in development)

[github.com/microbit-foundation/aarhus-ml-machine/](https://github.com/microbit-foundation/aarhus-ml-machine/)

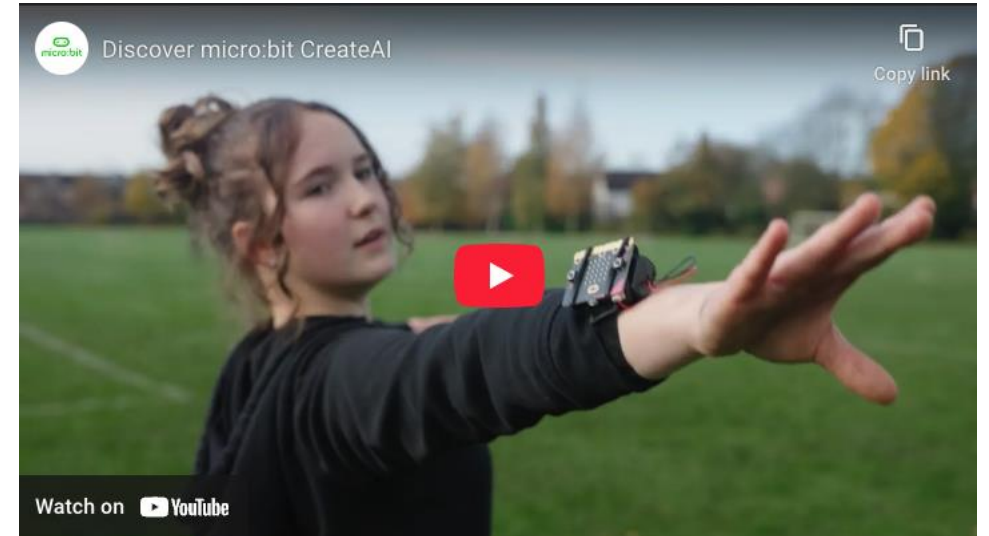
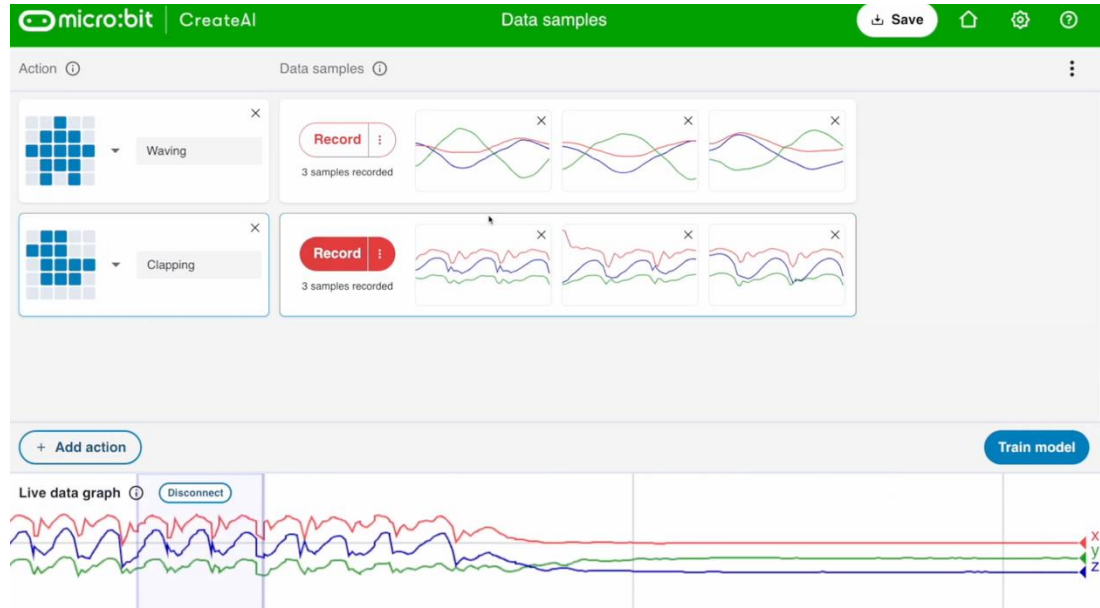


# math.ml-machine.org/

The image shows the ML-Machine web interface, which is a tool for building machine learning models. The interface is divided into several sections:

- Header:** The title "ML-Machine" is at the top left. On the top right, there are two tabs: "Neural network" and "KNN".
- Central Workflow:** A vertical blue bar contains four main steps: "Data", "Trainer", "Validate", and "Model". Arrows indicate a sequential flow from Data to Trainer, then to Validate, and finally to Model.
- Trainer Section:** A teal box labeled "Trainer" contains a diagram of a crosshair with four quadrants (triangle, circle, hexagon, diamond) and the text "Training done".
- Settings Panel:** A list of features to be used in the model is shown on the right side of the central bar. The features are: "Max values" (checked), "Minimum values" (unchecked), "Mean" (unchecked), "Standard deviati..." (unchecked), "Number of extre..." (unchecked), "Total acceleration" (unchecked), "Zero crossing rate" (unchecked), and "Root mean squa..." (checked). There are also checkboxes for "Neighbours (K)" (set to 3) and "Normalize" (checked).
- Scatter Plot:** A scatter plot on the right shows data points for three classes: "Shake" (blue circles), "Still" (orange circles), and "Circle" (green circles). The plot includes a legend and a "Fingerprint" section at the bottom right.
- Classes and Data Section:** On the left, there are three sections: "Classes", "Choice", and "Data". The "Classes" section lists "Shake", "Still", and "Circle". The "Choice" section has "Add Data" buttons. The "Data" section shows three data plots with waveforms and bar charts.
- Live Data Section:** At the bottom, there is a "Live" section showing real-time data. It includes a "Connect output micro:bit" button, a "Disconnect" button, and a "Fingerprint" section. The live data shows a red waveform and a "Live" indicator.

# createai.microbit.org/



This screenshot displays a grid of actions and their corresponding code blocks. The actions are 'jumping', 'rolling', and 'sleeping', each with a 'Recognition point' slider set to 0%. The code blocks are arranged in a sequence: 'on ML jumping start' (show icon, play giggle), 'on ML rolling start' (show icon, play melody at tempo 448 bpm in background), 'on ML sleeping start' (show icon, play twinkle), 'on ML unknown start' (clear screen), 'on ML jumping stop' (stop all sounds), 'on ML rolling stop' (stop all sounds), and 'on ML sleeping stop' (stop all sounds).

Four cards promoting micro:bit CreateAI resources:

- micro:bit CreateAI**: Create AI with movement and machine learning on your BBC micro:bit
- micro:bit CreateAI user guide**: Detailed information and guidance about using CreateAI
- micro:bit wearable**: Wear your micro:bit anywhere with a holder and strap.
- micro:bit CreateAI webinars**: Free short webinars introducing how to teach and learn with CreateAI

# [createai.microbit.org/](https://createai.microbit.org/)



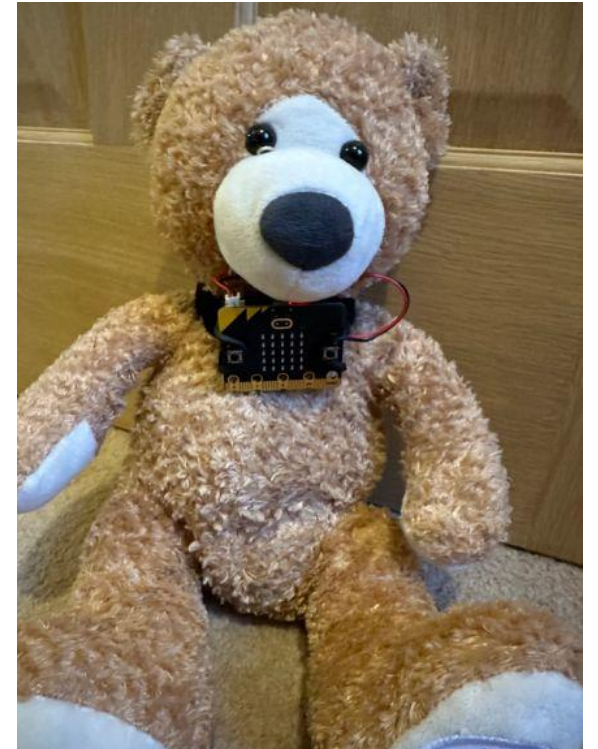
**AI storytelling friend**



**Simple AI exercise timer**



**AI activity timer**




# Building educational material around the embodied activities

Undervisningsmateriale om kunstig intelligens i din hverdag

dr.dk/skole/ultra-bit/udskoling/tema/kunstig-intelligens-i-din-hverdag


**Tema: Kunstig intelligens på sociale medier**

Kender du det, når dit feed på sociale medier rammer plet med de billeder og videoer, det viser dig? Det kan måske virke som noget hokus pokus, men i virkeligheden er det et eksempel på brug af kunstig intelligens, der teknisk kaldes machine learning. Det skal I lære meget mere om nu. Undervejs skal I se explainer-videoer, analysere jeres feed på sociale medier, forholde jer kritisk til hvordan algoritmerne påvirker jeres digitale liv samt lave jeres første machine learning-model med en BBC micro:bit og værktøjet 'ultra:bit datatræneren'.




ULTRA-BIT UDSKOLING | 4:1 MIN. SIDEN

**DEL 1:** Kunstig intelligens styrer dit feed på sociale medier




MACHINE LEARNING



Til læreren

ULTRA-BIT UDSKOLING | 4:2 MIN. SIDEN

Om 'Kunstig intelligens på de sociale medier'



ANALYSEFEED

ULTRA-BIT UDSKOLING | 4:3 MIN. SIDEN

**DEL 2:** Analyser dit feed på de sociale medier





# Unintentional bias



Undesired content on social media



# Data Representativeness



Self-driving cars



Google tags photos incorrectly



# Enacting key challenges in developing and implementing machine learning systems

## Unintended biases



Machine learning machine



ml-machine.org

## Data representativeness

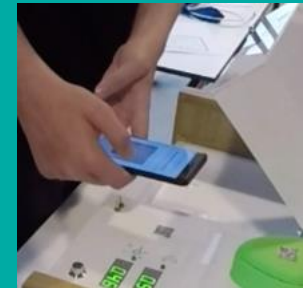


ml-machine.org



Critical data intervention

## Impact of parameters




Machine learning machine

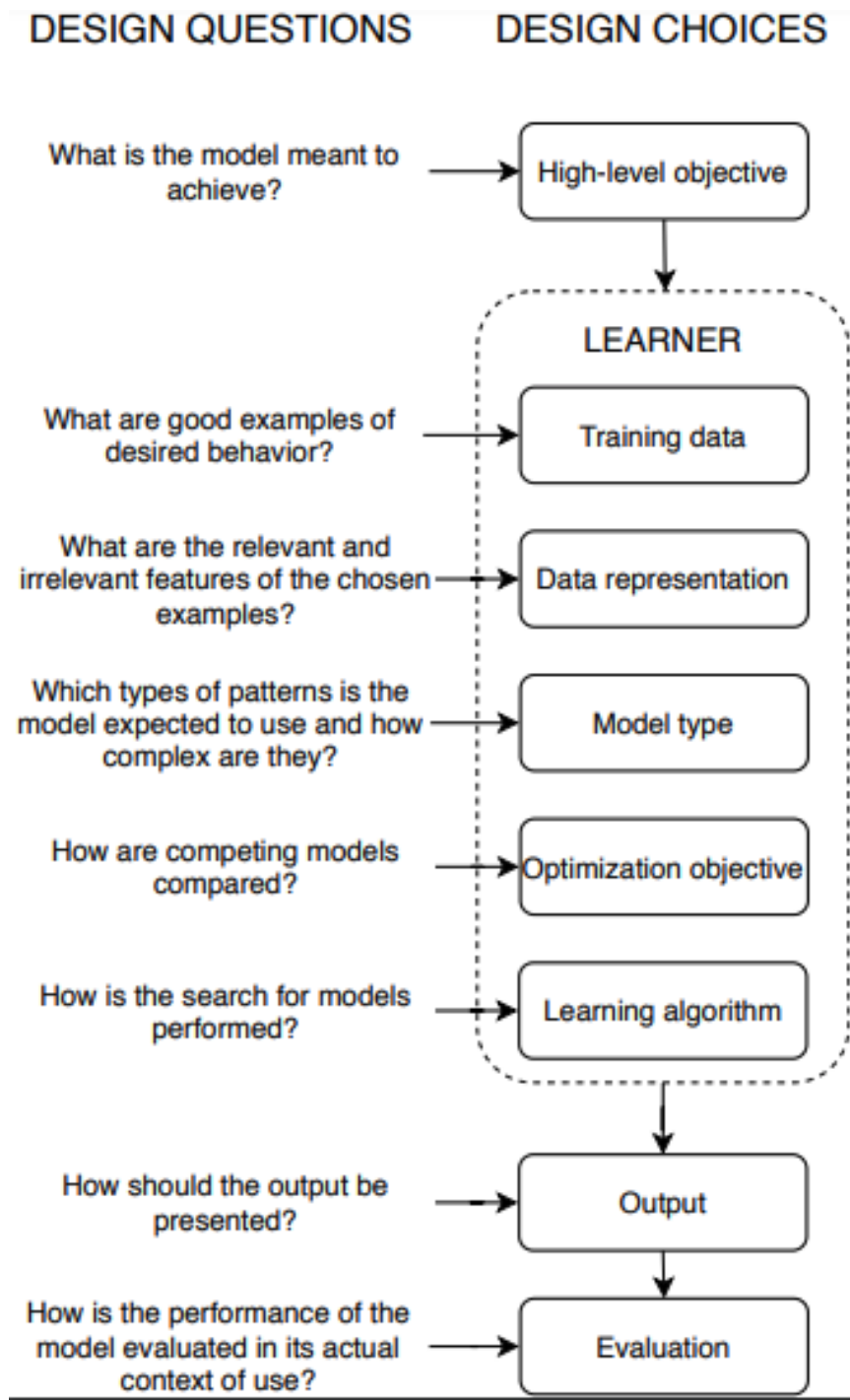


Critical data intervention

from

**DEMO**  **DESIGN**

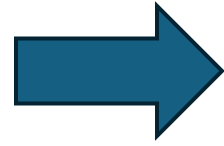
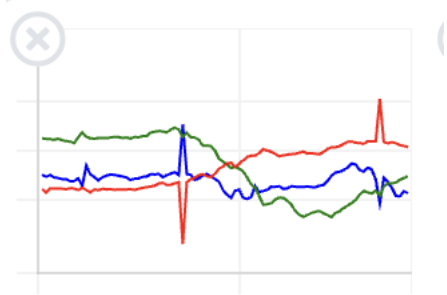
in teaching machine learning



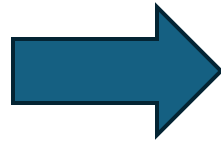
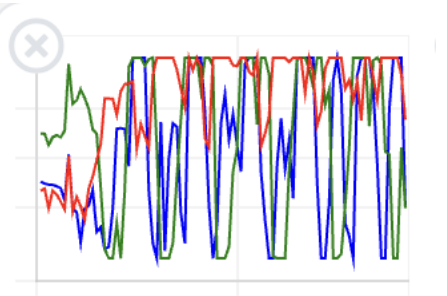


How does this relate to  
chatbots?

# Machine learning: Predict the next symbol



Triangle

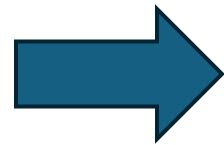
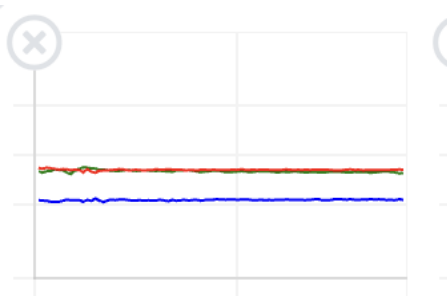


Shake

What is the next word in this...

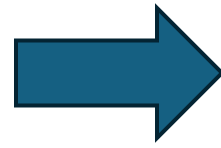
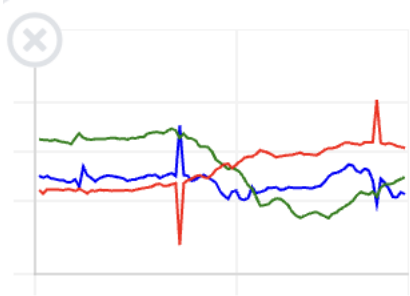


sentence

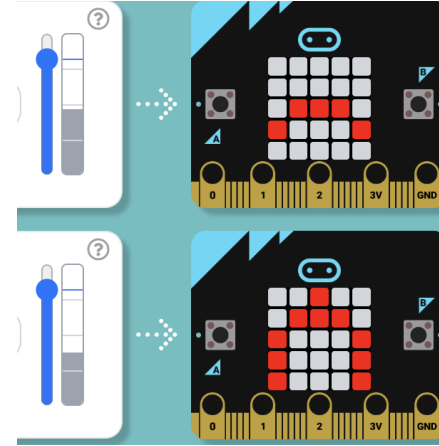


Inactive

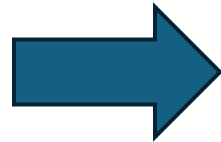
# How do we choose the next word?



Triangle  
Shake  
Still

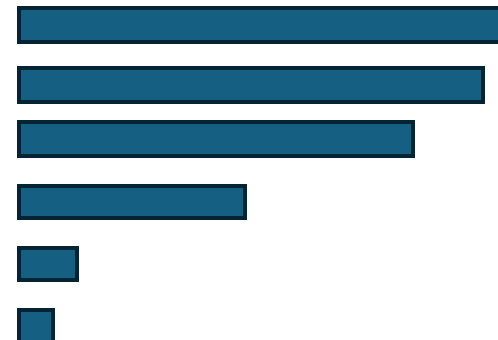


What is the next word in this...



sentence  
book  
novel  
compound  
washing machine  
or  
...

Probability



# Generating new sentences with our model 🤖

What is the next word in this → 🤖 → book

is the next word in this book → 🤖 → about

the next word in this book about → 🤖 → physics

next word in this book about physics → 🤖 → ?

What is the next word in this book about physics?



# The Engine Room

[maskinrummet.github.io/#/en](https://maskinrummet.github.io/#/en)



Luke John Connelly

Connelly et al. 2025. Beyond LLMs as Black Boxes: Activities and an Educational Tool Supporting Unplugged and Digital AI Learning Activities for K-12 Classrooms. In Adjunct Proceedings of the Sixth Decennial Aarhus Conference: Computing X Crisis (AAR Adjunct '25).

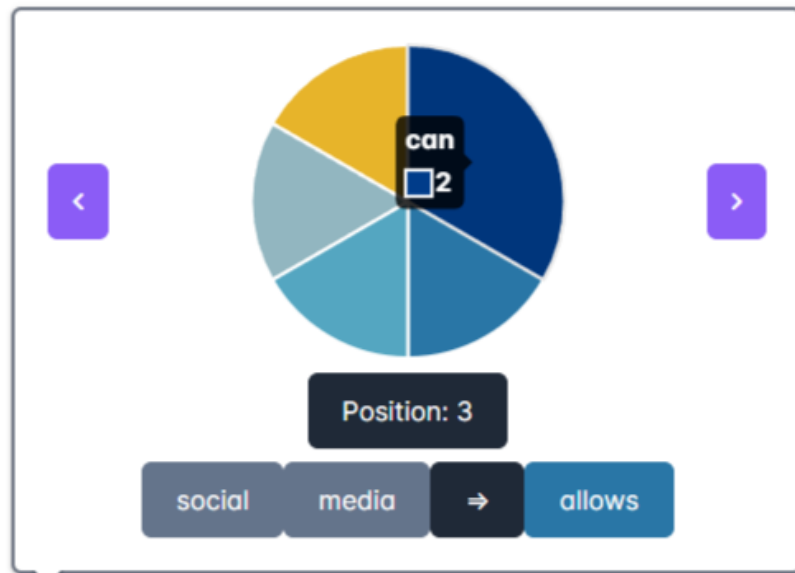


# Teaching natural language processing (NLP)



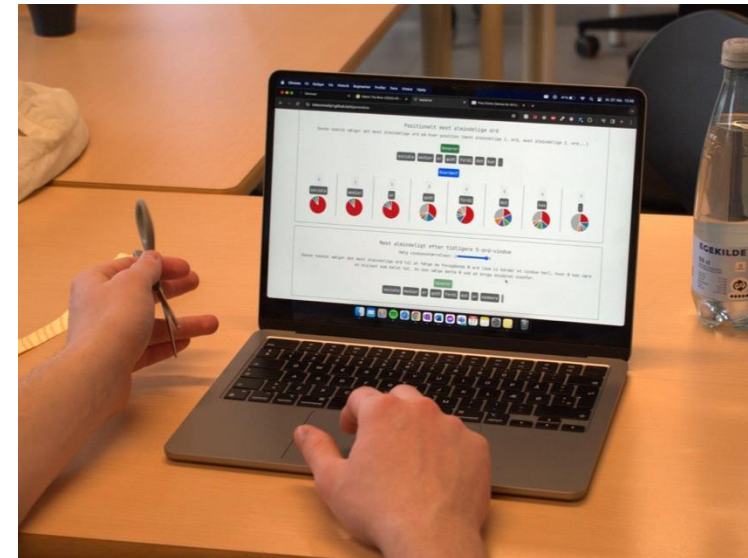
# Teaching natural language processing (NLP)

[maskinrummet.github.io/#/en](https://maskinrummet.github.io/#/en)



social media allows people to express themselves  
and share their creativity with others [END]

social and  
for to  
media  
can a allows of  
with people in  
users communities  
share sense sectors platform platforms  
resources regardless





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