

Embodied approaches to teaching machine learning concepts and practices

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

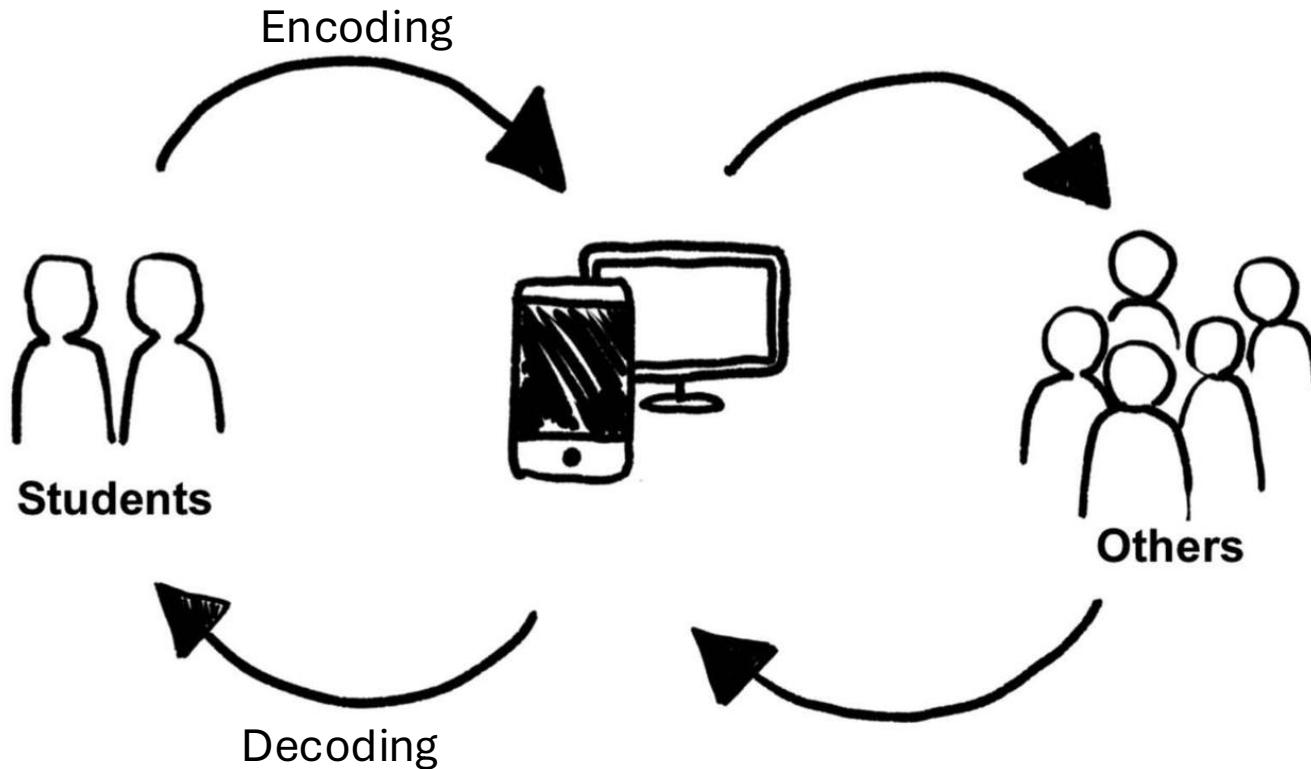
Designing non-programming interfaces
(and activities) that make machine learning
more graspable and explorable.

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

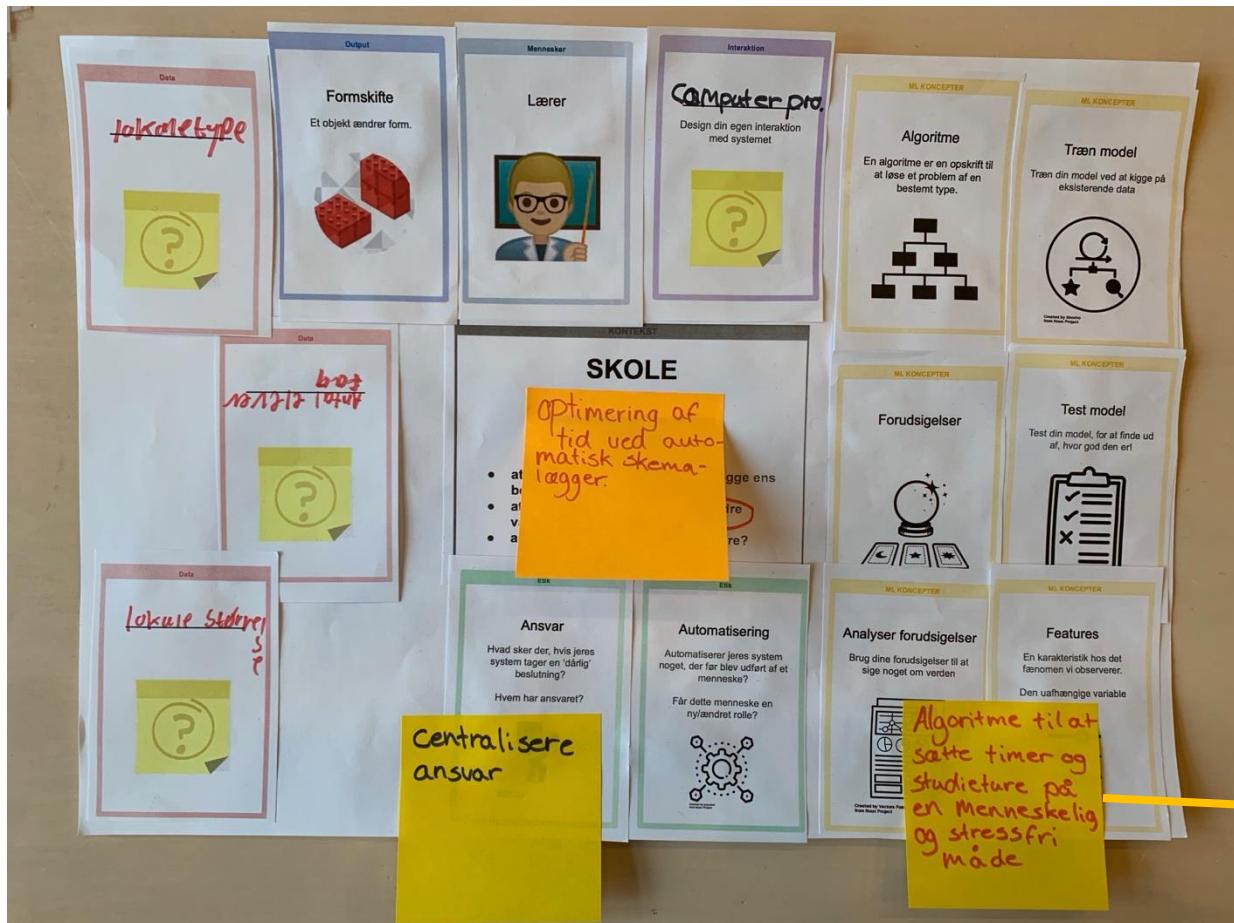
Disseminating new ways to engage with
machine learning technologies in
classrooms.



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

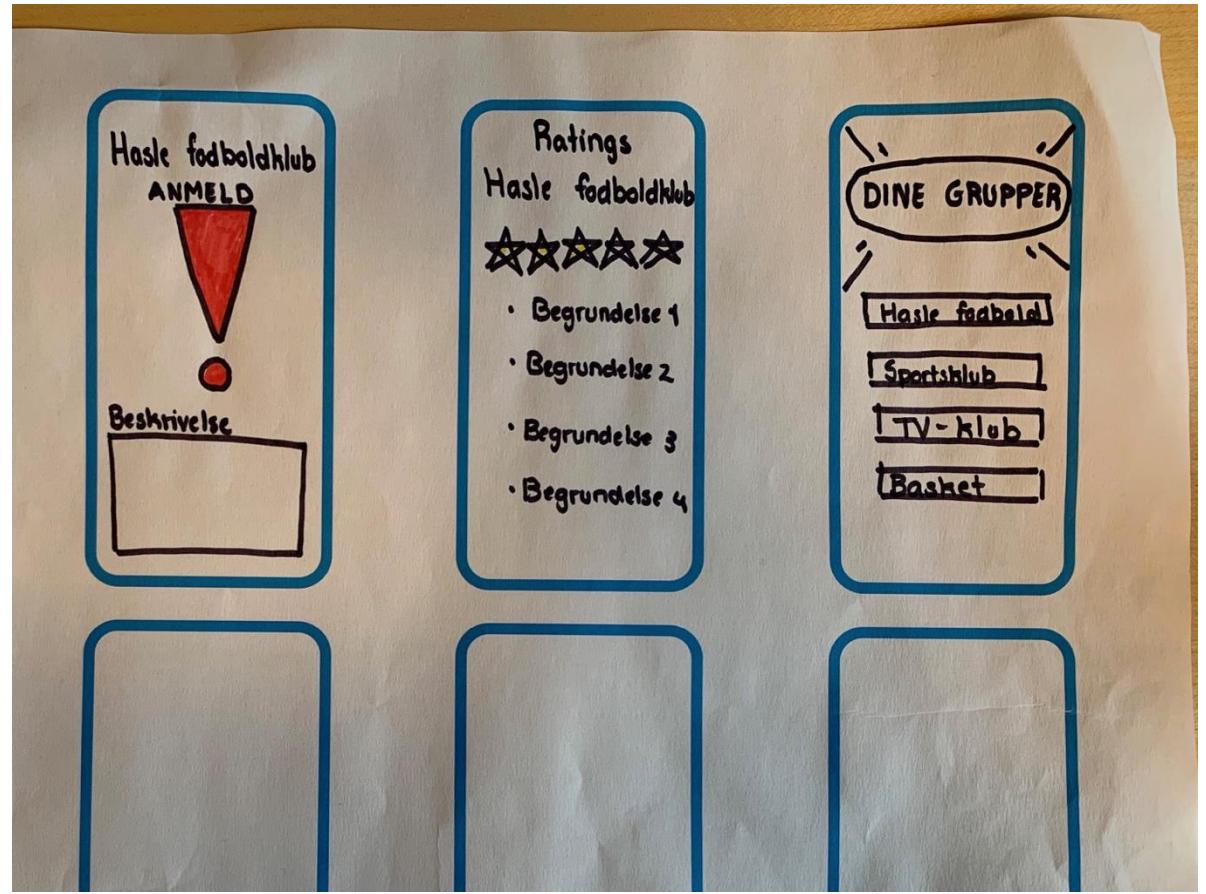
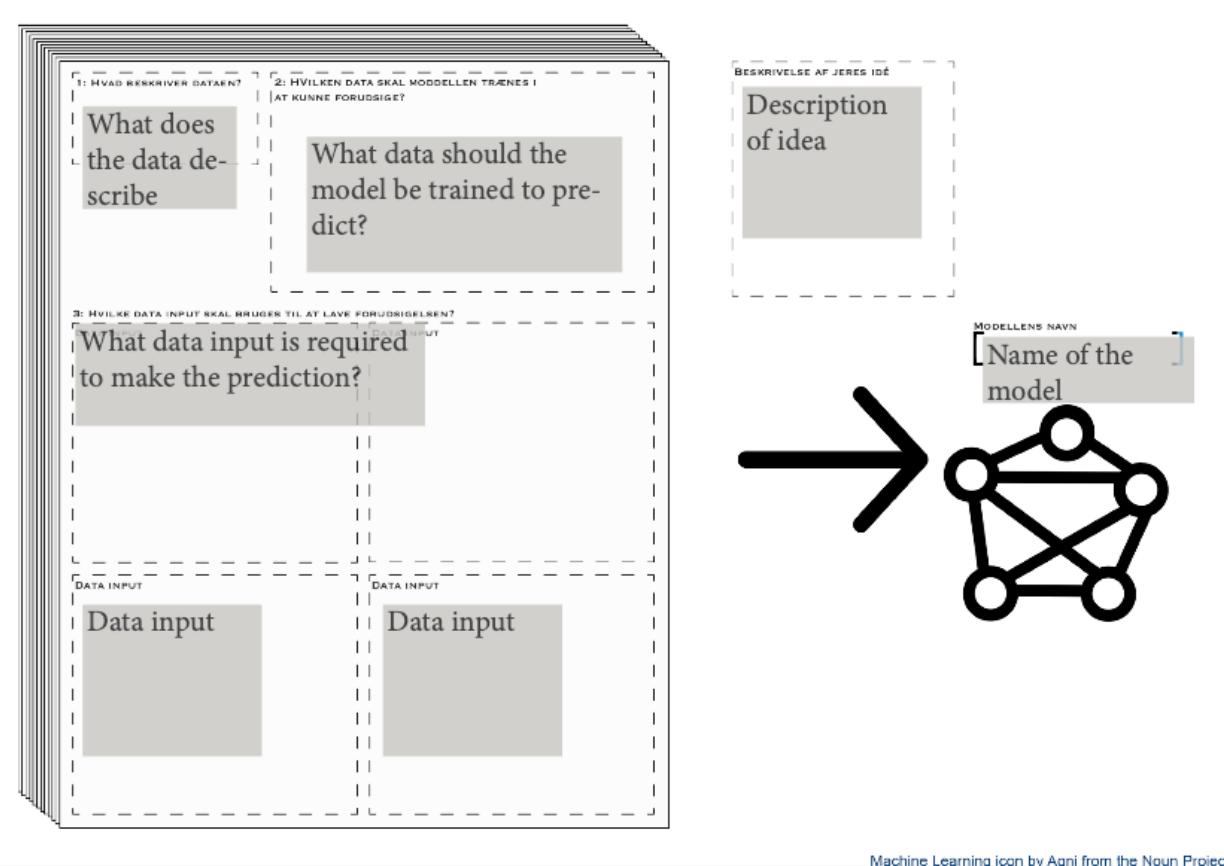


Machine learning ethics cards workshop



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





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

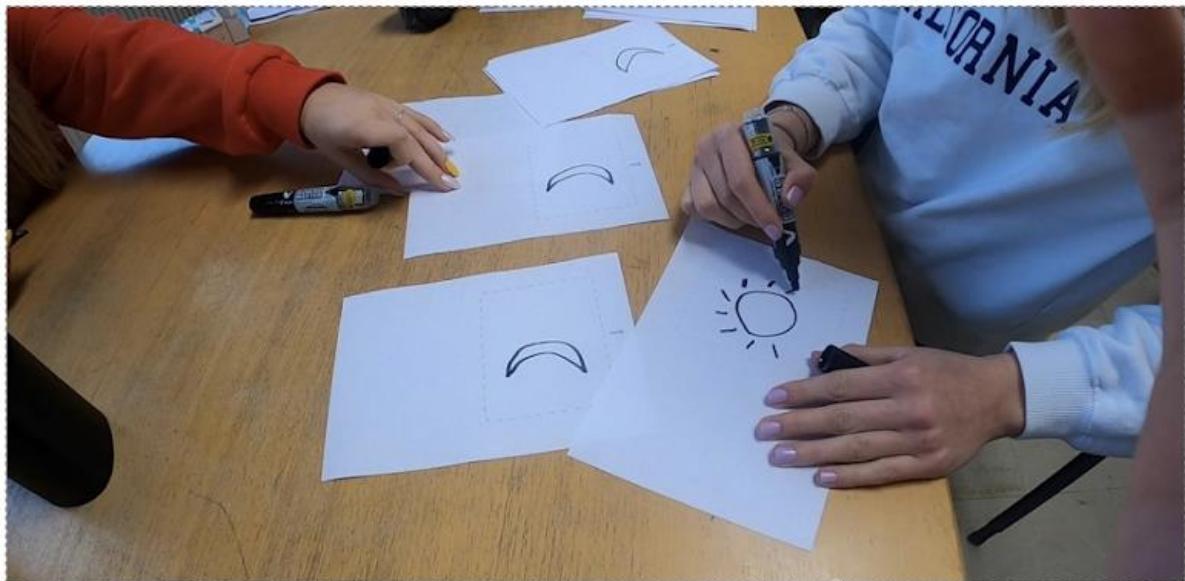
Engaging with ethical dilemmas through design decisions nad hands-on activities

Enacting Machine learning
practices in the classroom

Machine learning machine

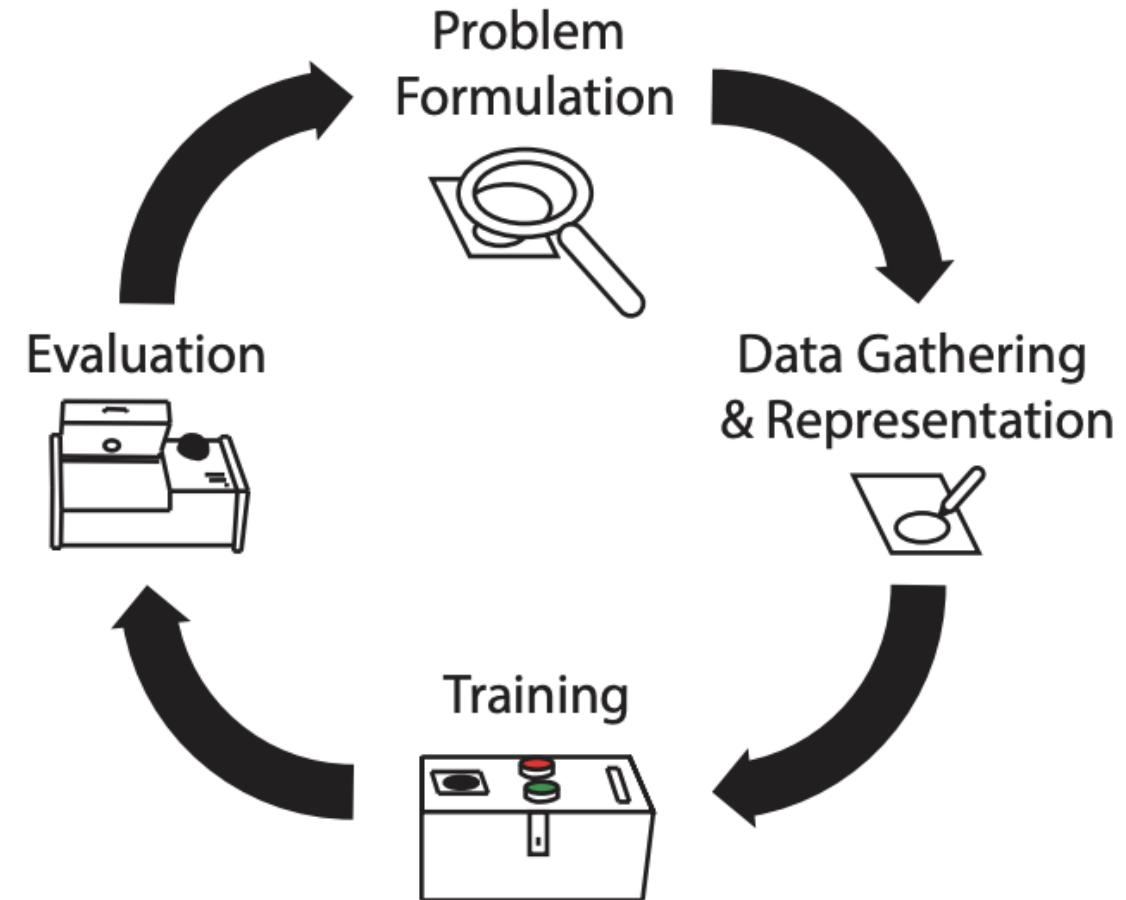


[Kaspersen et al., The Machine Learning Machine: A Tangible User Interface for Teaching Machine Learning, TEI 2021]



Design rationale

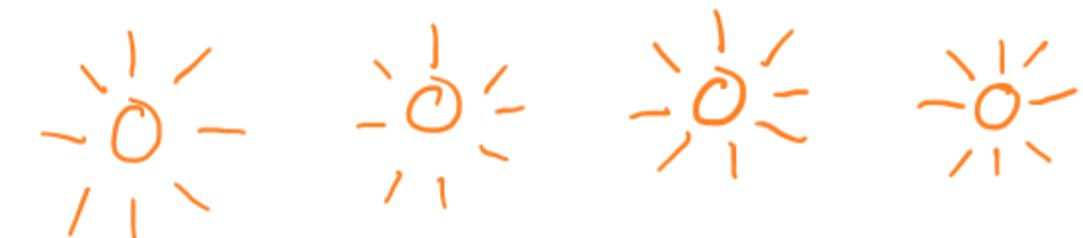
- Mystical boxes in the physical classroom
- Low floor
- Experiment and iterate to explore the boxes functionality
- Powerfull tools → slow interaction



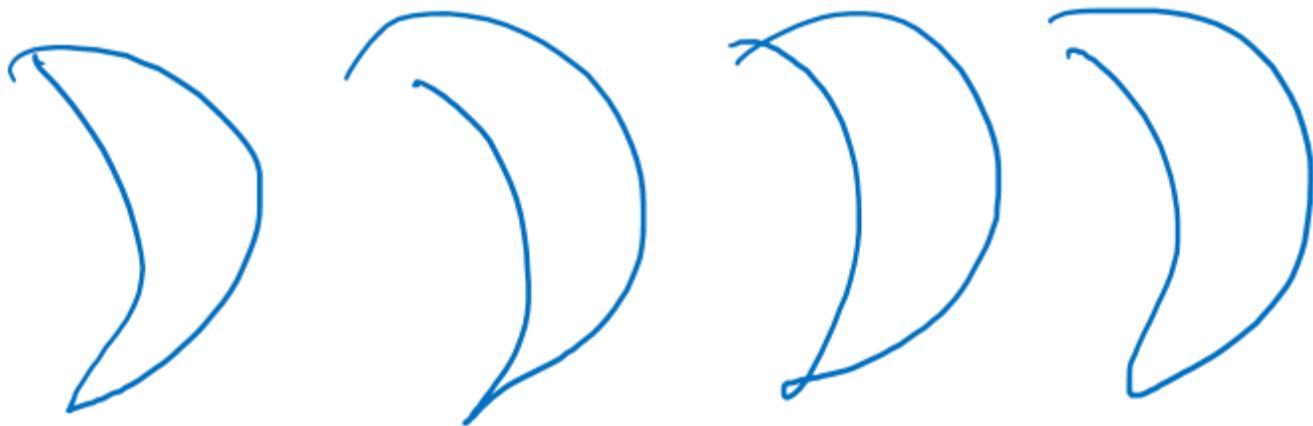
Unintended Biases



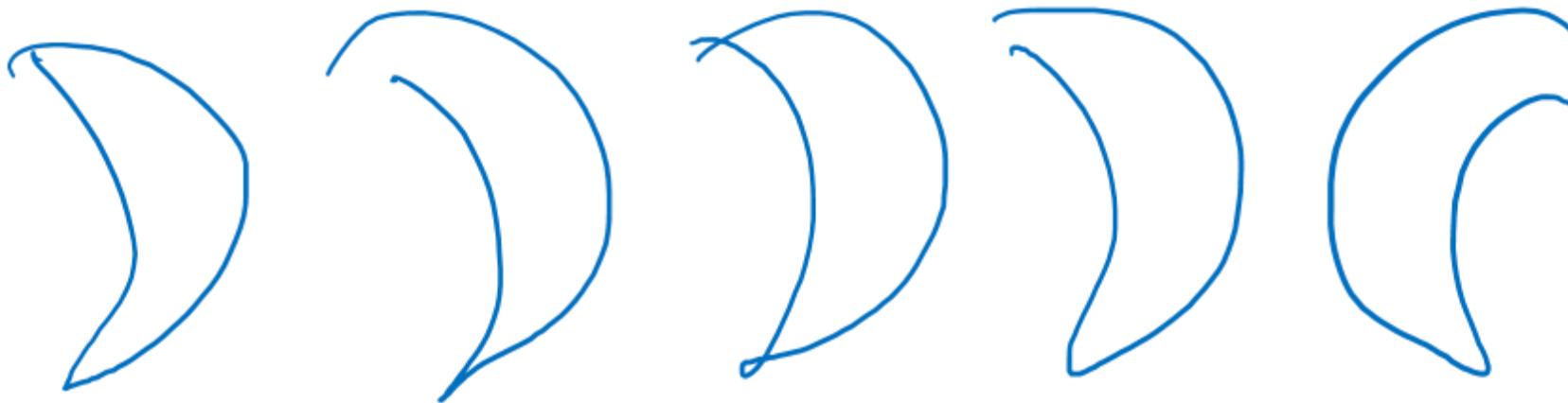
Unintended Biases



Data Representativeness



Data Representativeness



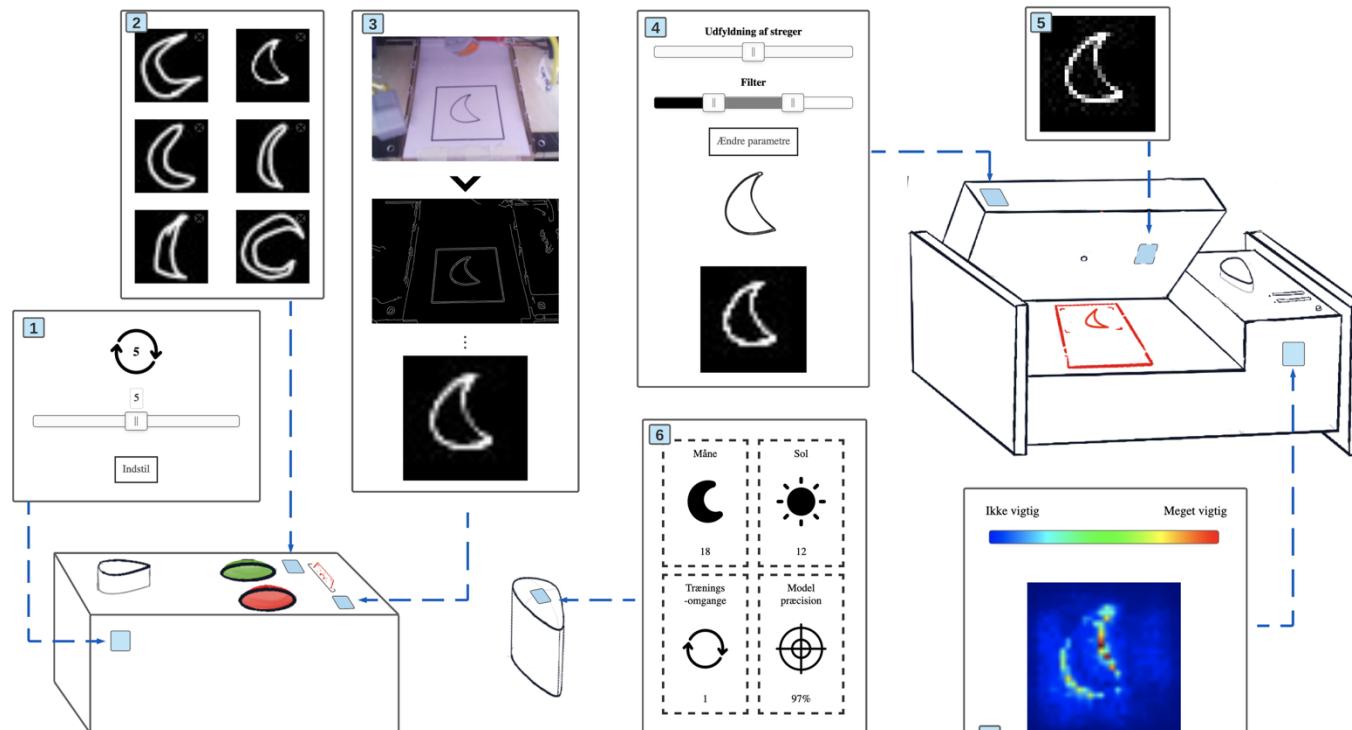
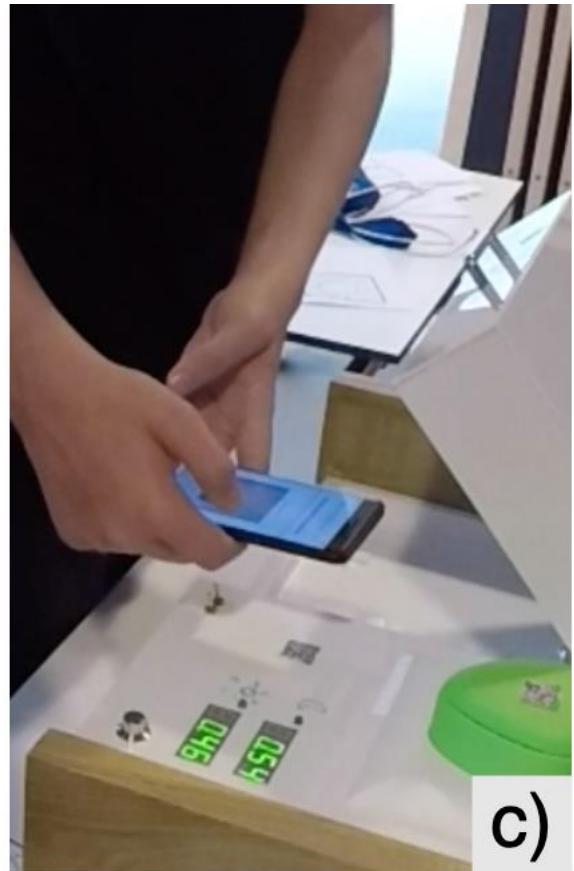
Limitations

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



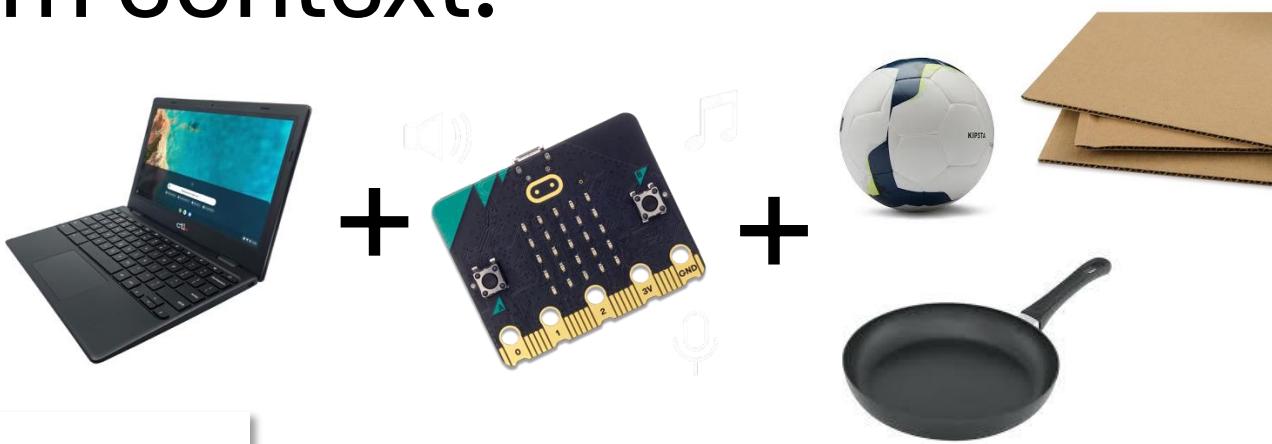
Iconic



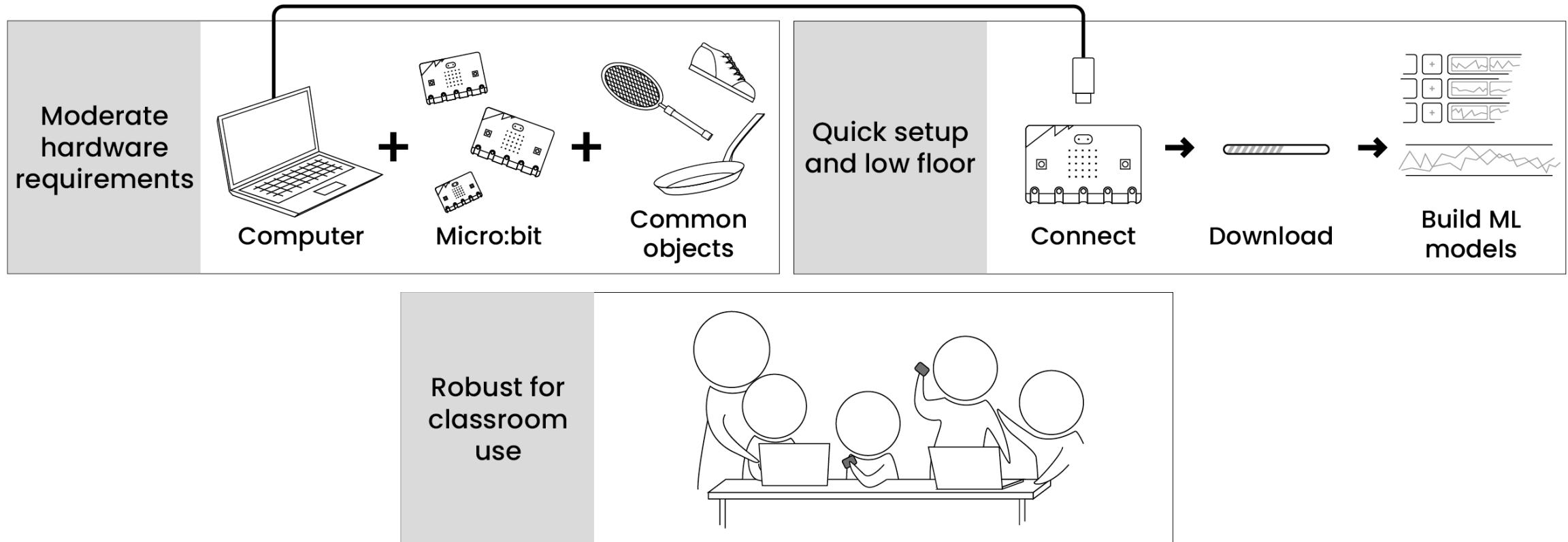
Abstract

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

Design for the classroom context: ml-machine.org/



Design for the classroom context: ml-machine.org/

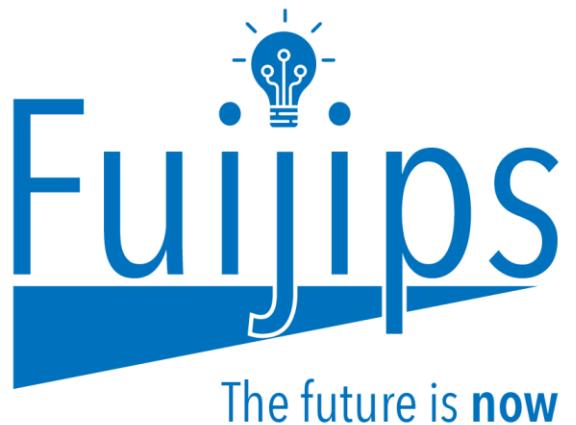
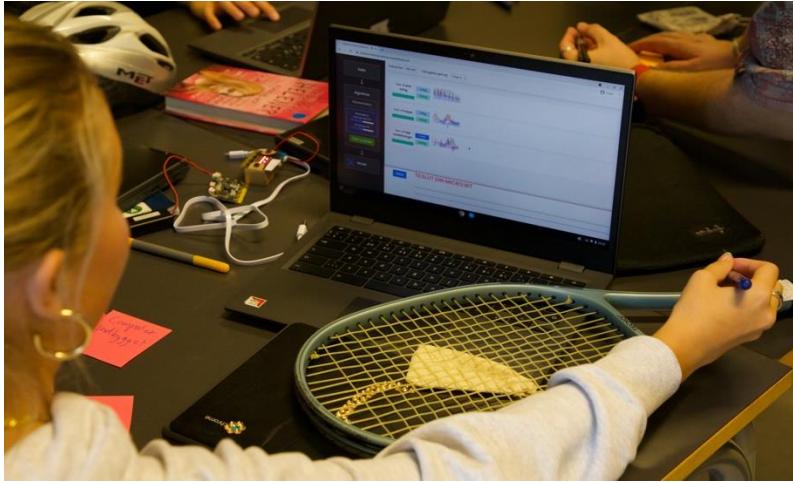
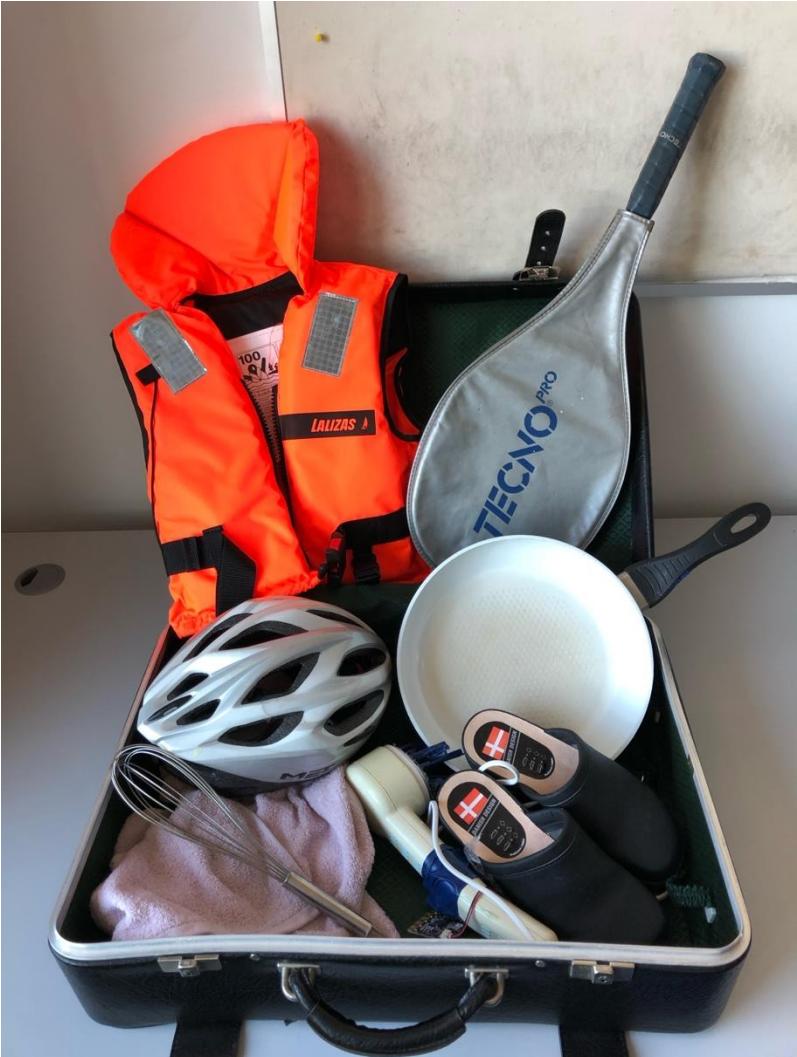


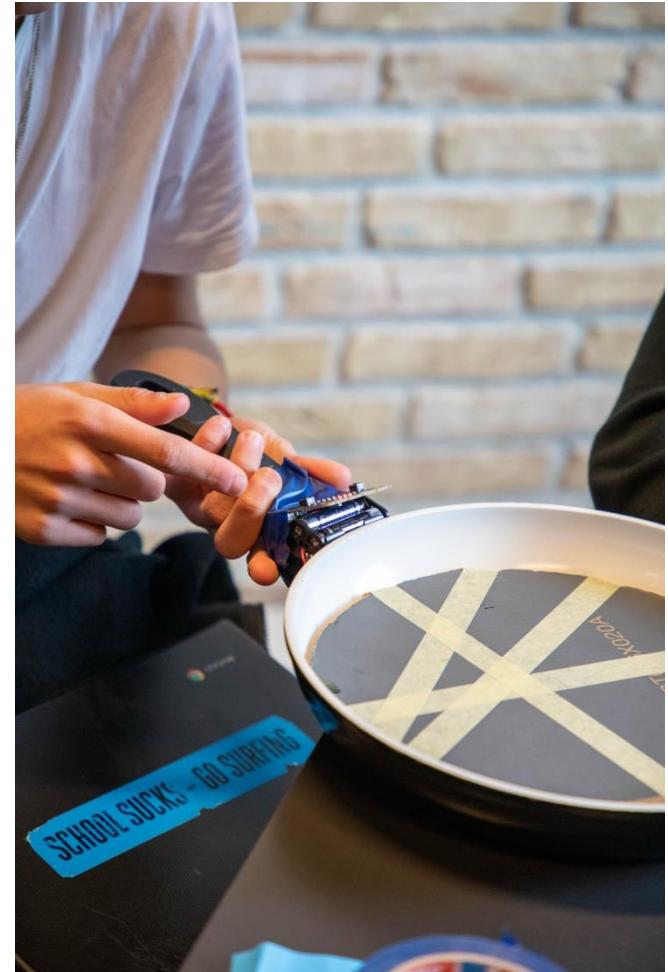
[Bilstrup et al., The ML-Machine Toolkit: Empowering Teachers and Education Professionals to Explore Embodied Approaches to Teaching Machine Learning, DIS 2025]

Demo

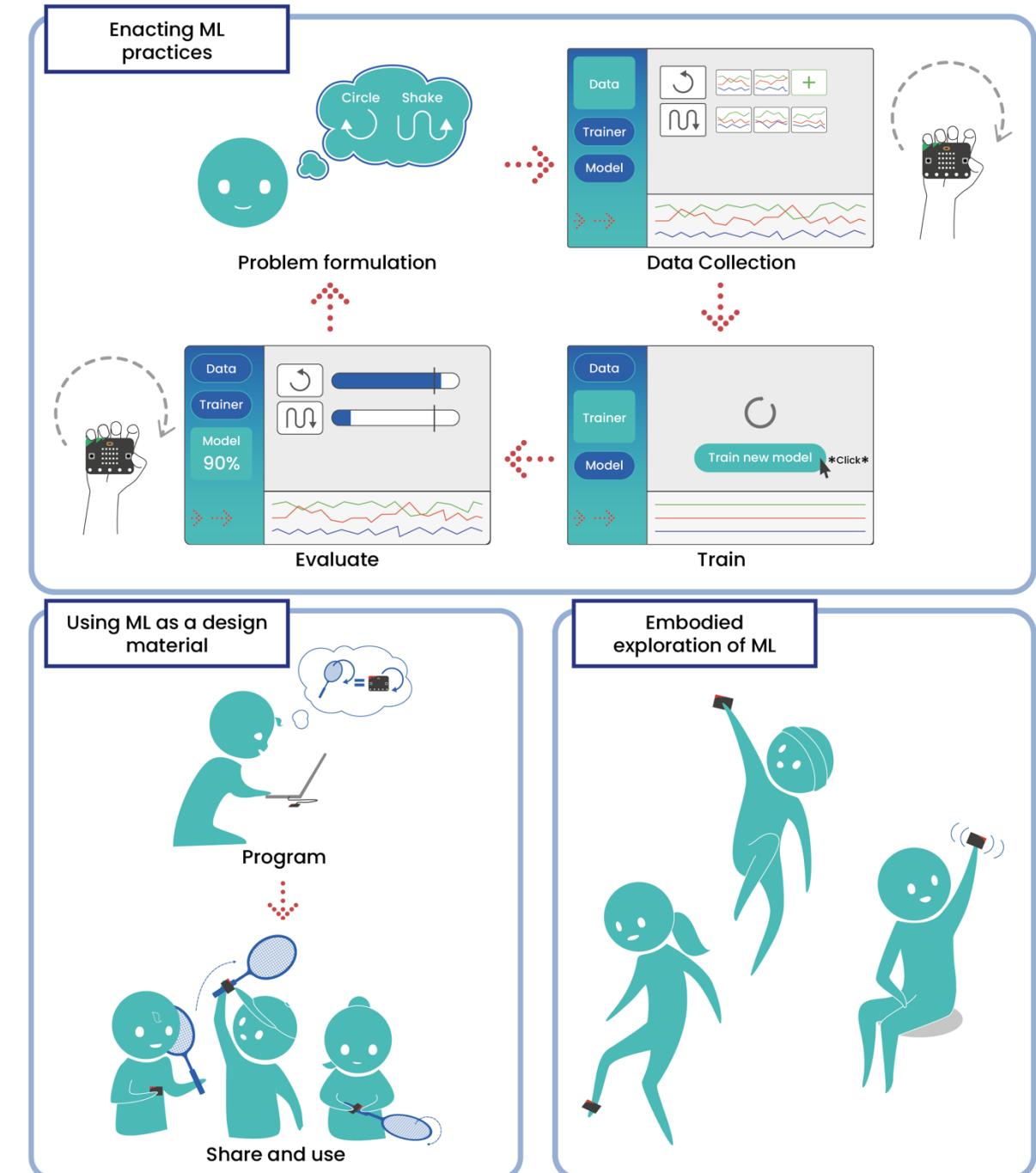
ml-machine.org/

Machine learning as a design material

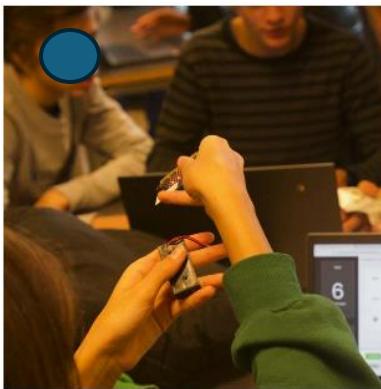




Learning about machine learning through embodied interaction



Working with multiple representations and abstractions



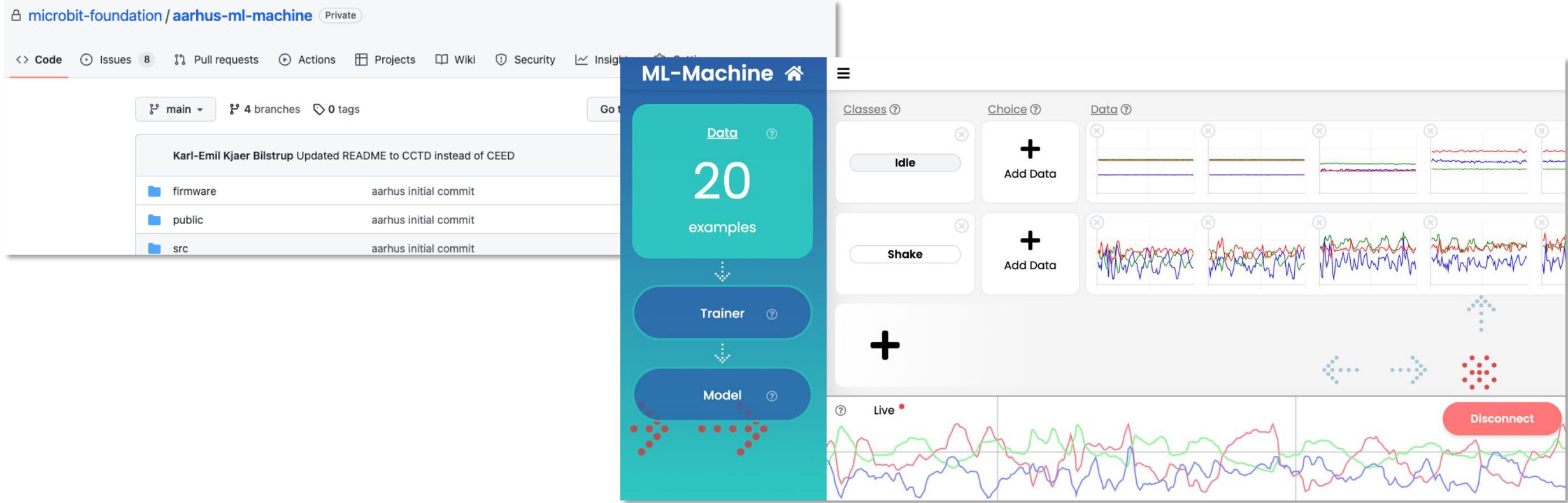
Finding patterns in
accelerometer data



Train ML model to
recognize bodily activity



Redesign a physical
artefact with ML



ml-machine.org/

math.ml-machine.org/ (in development)

github.com/microbit-foundation/aarhus-ml-machine/

math.ml-machine.org/

The image shows a screenshot of the ML-Machine web application interface. The interface is divided into several sections:

- Left Panel:** Contains buttons for "Classes" (Shake, Still, Circle), "Choice" (Add Data), and "Data" (Add Data). Each category has a corresponding visualization: a 3D bar chart for Classes, a 2D scatter plot for Choice, and a 3D bar chart for Data.
- Central Panel:** A large teal box labeled "ML-Machine" with a house icon. It contains four main steps:
 - Data:** Shows a 3D bar chart.
 - Trainer:** Shows a 2D scatter plot with three data points (triangle, circle, diamond) and the text "Training done".
 - Validate:** Shows a 3D bar chart.
 - Model:** Shows a 3D bar chart.
- Right Panel:** A detailed view of the "Trainer" step.
 - Parameter List:** Includes checkboxes for "Max values" (checked), "Minimum values", "Mean", "Standard deviation", "Number of extremes", "Total acceleration", "Zero crossing rate", and "Root mean square" (checked).
 - For "Max values": Neighbours (k) = 3, Max values = 2.19, Root mean square = 0.58.
 - For "Root mean square": X: 0.14, Y: 0.36, Z: -1.23.
 - Plot:** A 2D scatter plot with a green vertical line at X ≈ 0.36. The plot shows data points for "Shake" (blue), "Still" (red), and "Circle" (green). The x-axis has ticks at 33.3%, 0.0%, and 66.7%.
 - Bottom:** Buttons for "Connect output micro:bit" and "Disconnect", and a "Fingerprint" section with a small icon.

createai.microbit.org/

micro:bit CreateAI

Data samples

Action Waving

Record 3 samples recorded

Waving

Action Clapping

Record 3 samples recorded

Clapping

+ Add action

Train model

Live data graph Disconnect

jumping

Recognition point: 0%

rolling

Recognition point: 0%

sleeping

Recognition point: 0%

on ML jumping start

show icon play giggle until done

on ML rolling start

show icon play melody at tempo 440 in background

on ML sleeping start

show icon play twinkle until done

on ML unknown start

clear screen

on ML jumping stop

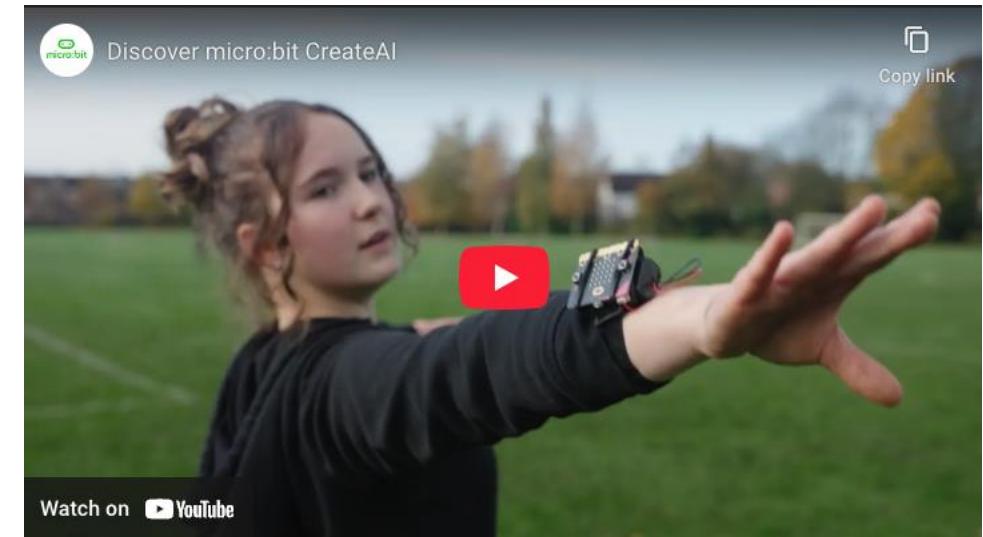
stop all sounds

on ML rolling stop

stop all sounds

on ML sleeping stop

stop all sounds



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/



AI storytelling friend



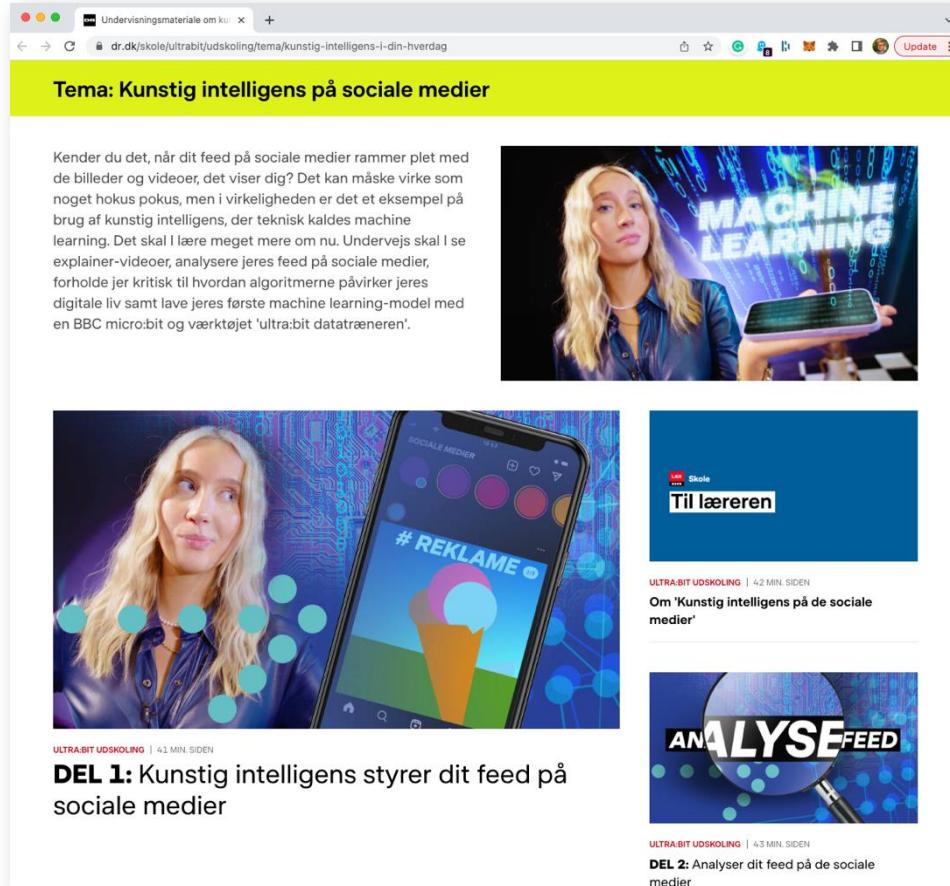
Simple AI exercise timer



AI activity timer



Building educational material around the embodied activites



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. Undeveis 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 værktojet 'ultra:bit datatræneren'.

ULTRA-BIT UDSKOLING | 41 MIN. SIDEN
DEL 1: Kunstig intelligens styrer dit feed på sociale medier

ULTRA-BIT UDSKOLING | 42 MIN. SIDEN
Om 'Kunstig intelligens på de sociale medier'

ULTRA-BIT UDSKOLING | 4,5 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

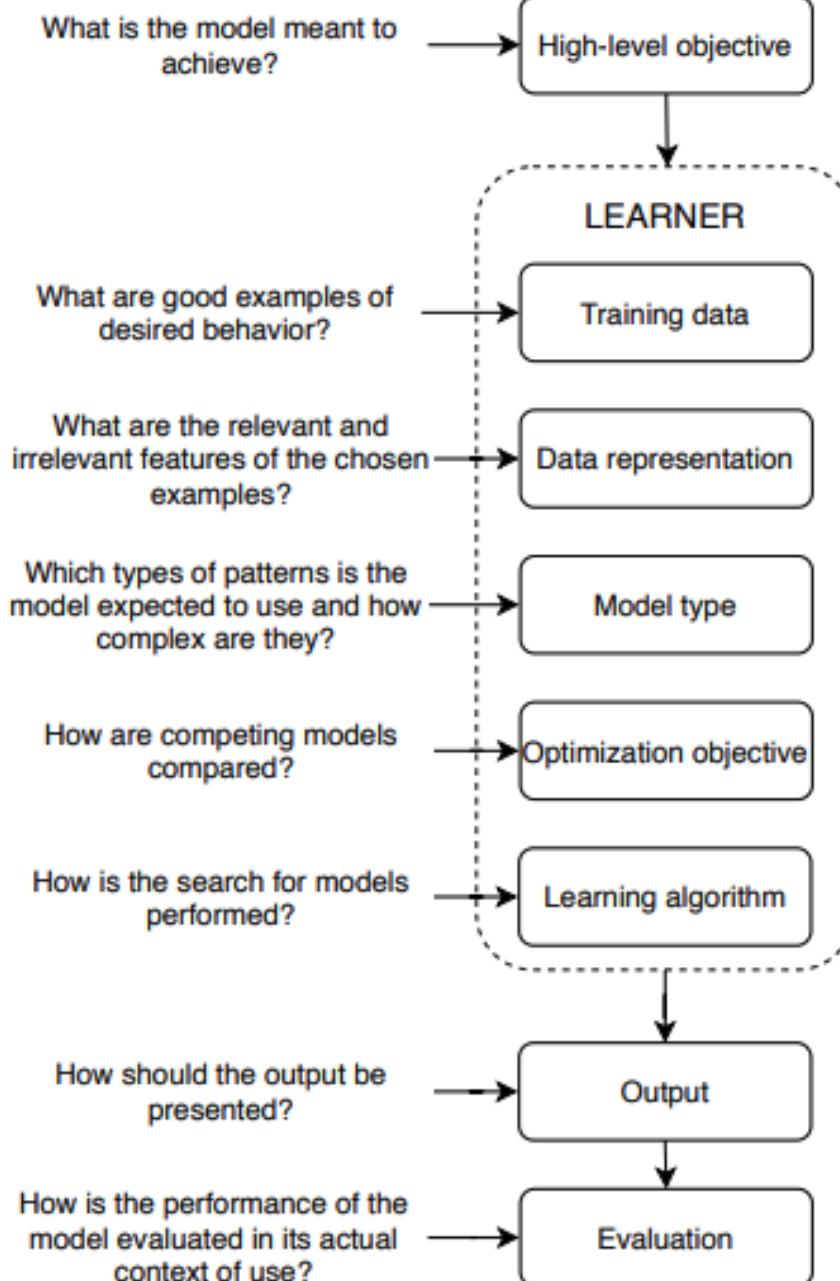


Machine learning machine



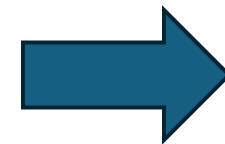
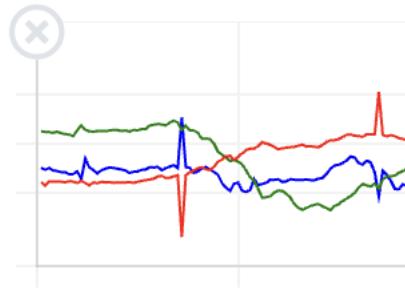
Critical data intervention

from
DEMO → **DESIGN**
in teaching machine learning

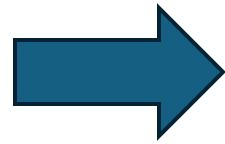
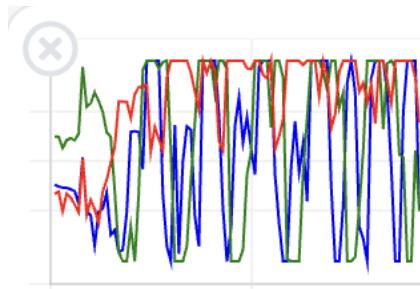


How does this relate to
chatbots?

Machine learning: Predict the next symbol



Triangle

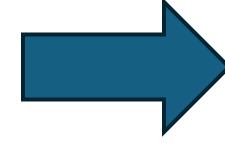


Shake

What is the next word in this...

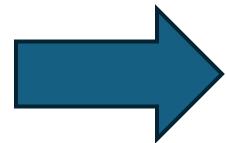
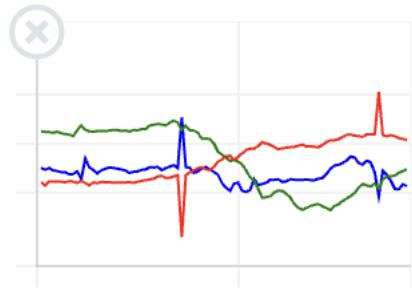


sentence

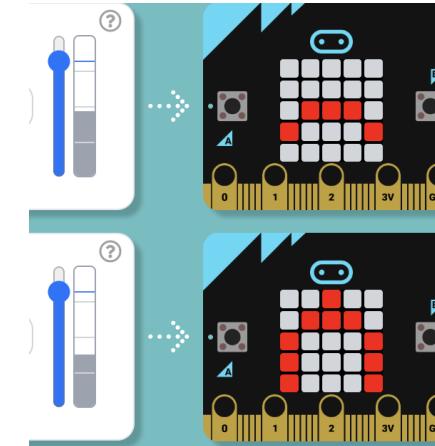


Inactive

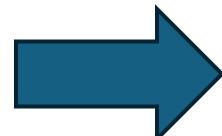
How do we choose the next word?



Triangle
Shake
Still

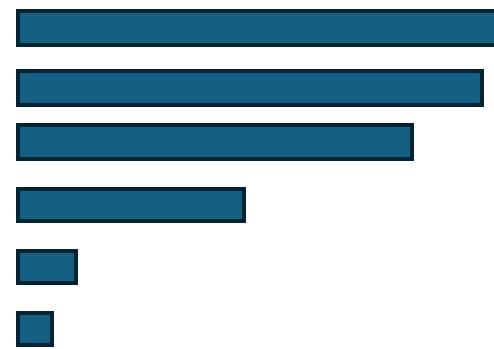


What is the next word in this...



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



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).

Luke John Connelly

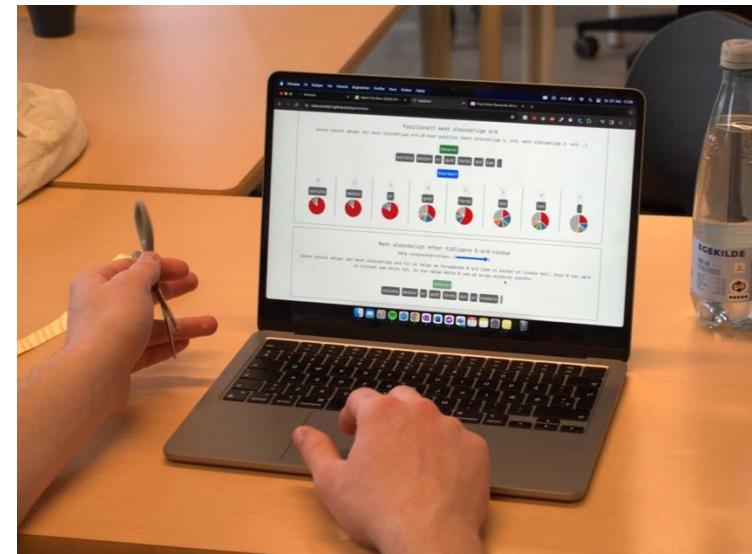
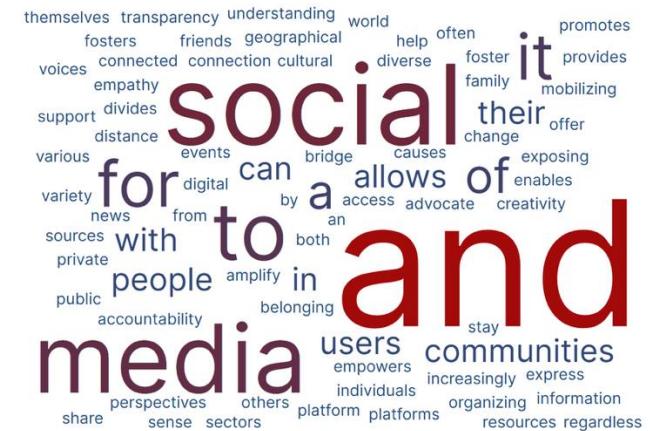
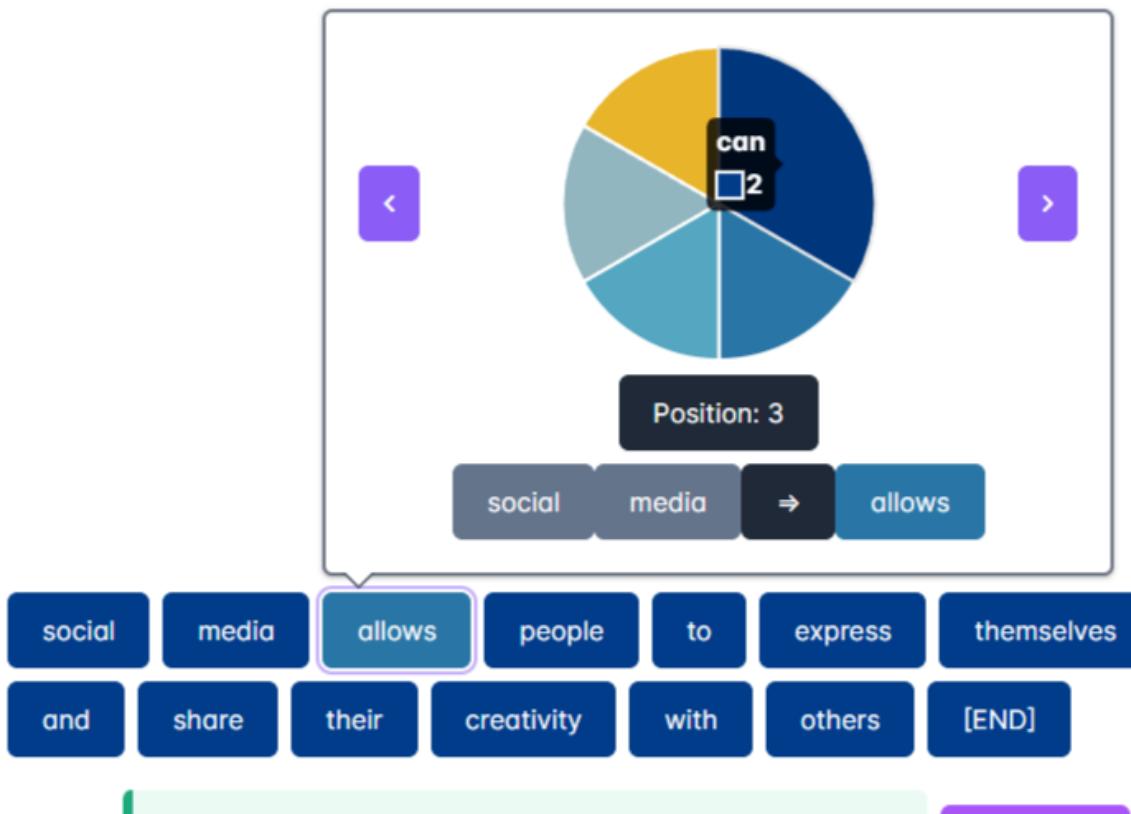


Teaching natural language processing (NLP)



Teaching natural language processing (NLP)

maskinrummet.github.io/#/en



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