Embodied approaches to teaching machine learning concepts and practices

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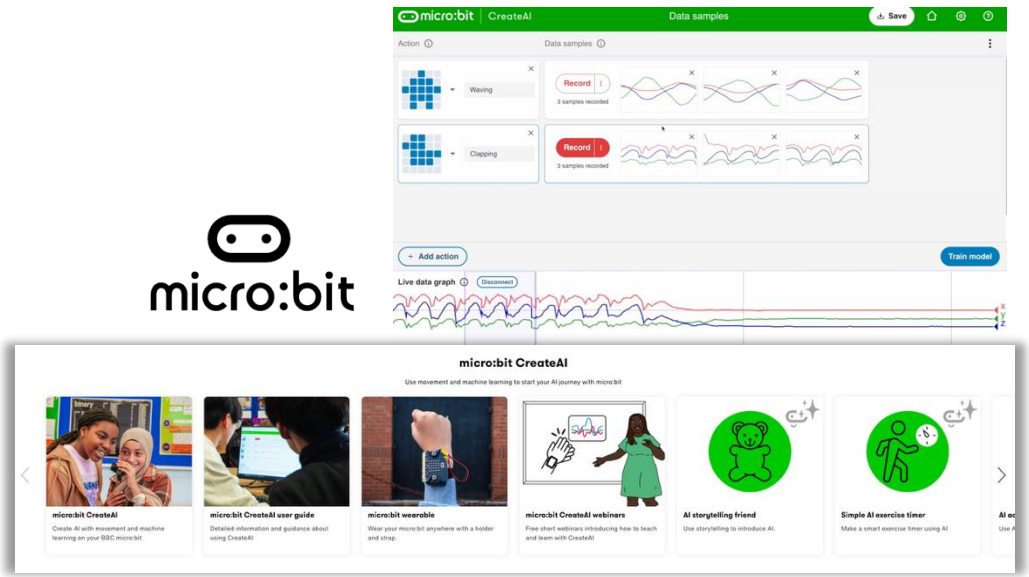
AI literacy in K-12 education
(How I work with it)

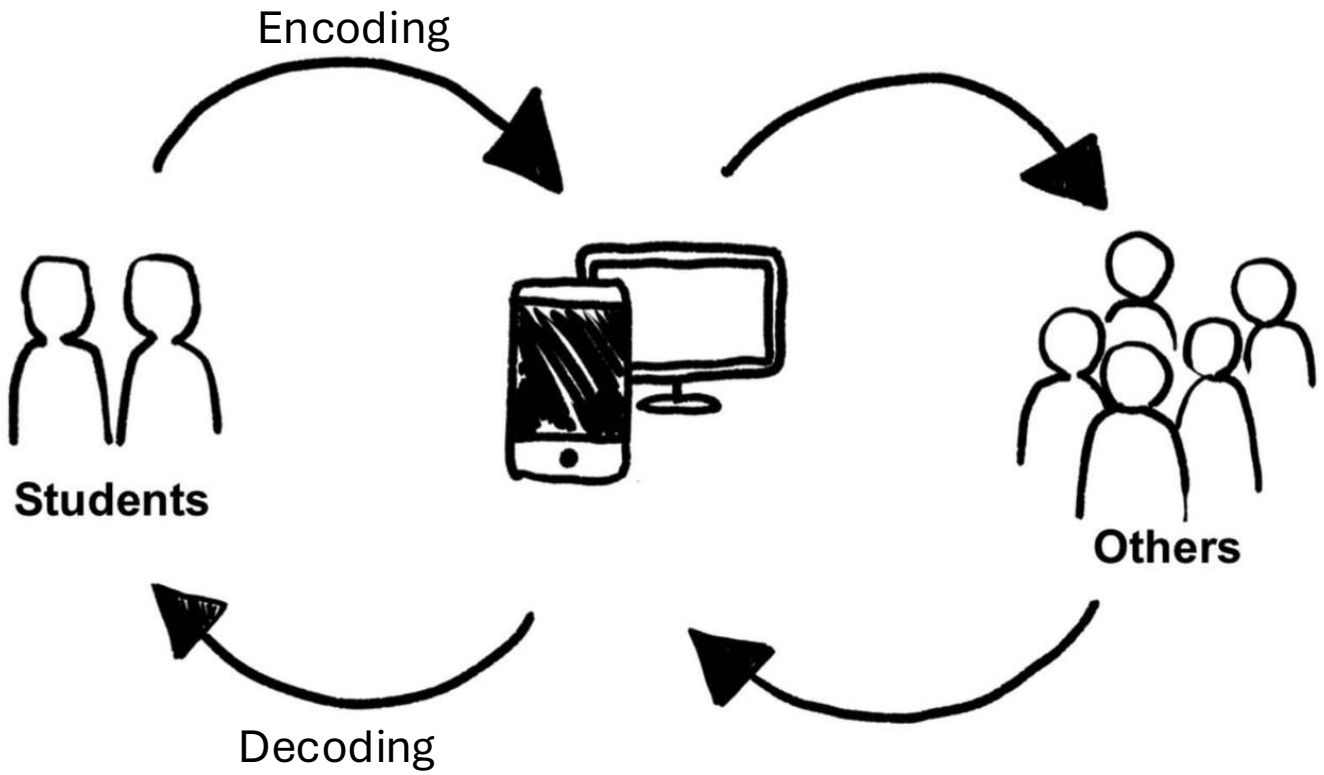
Designing non-programming interfaces (and activities) that make machine learning more graspable and explorable.

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.

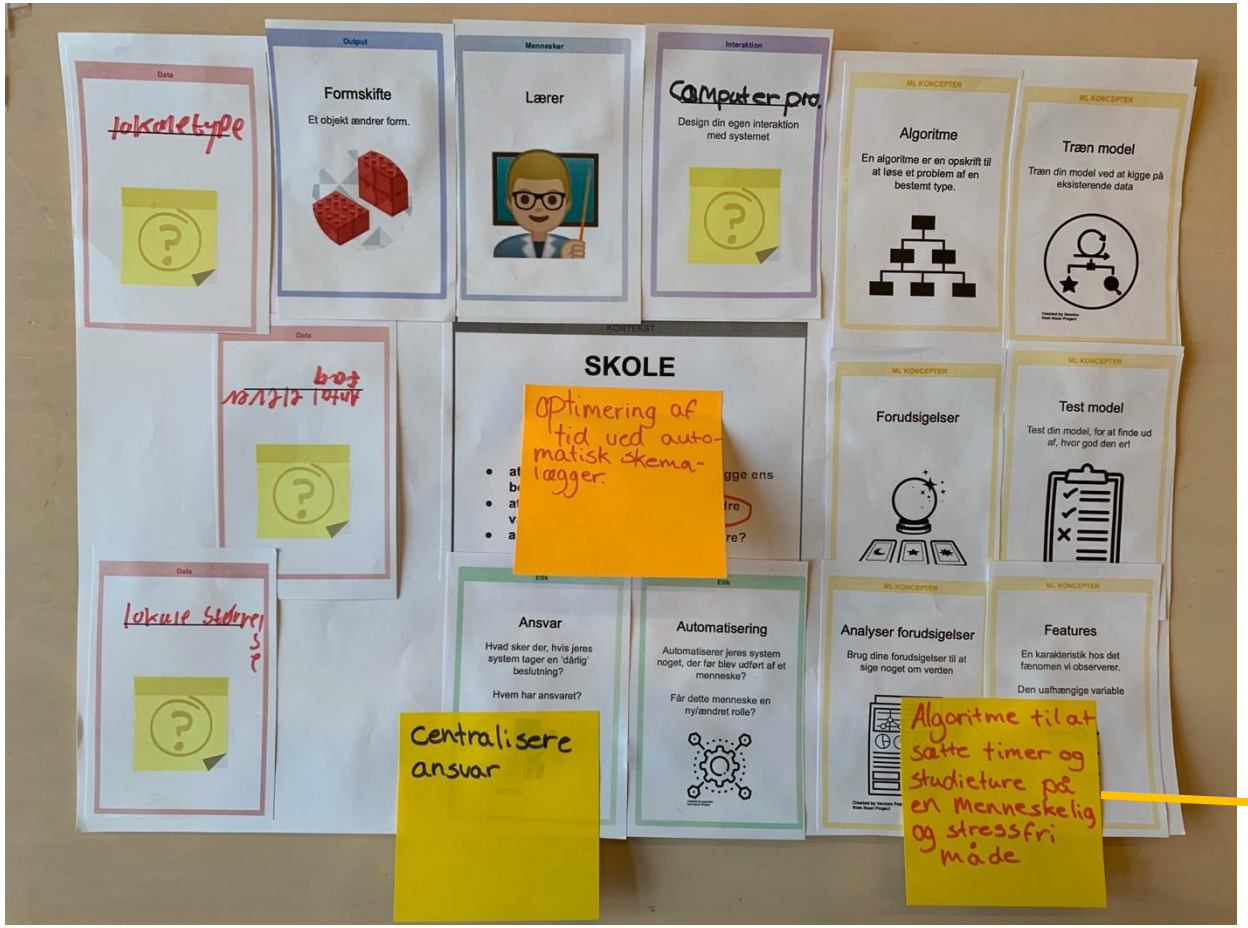


Computational empowerment - Sustaining students' (and teachers') agency in an increasingly *digitized* and *computationalized* world.



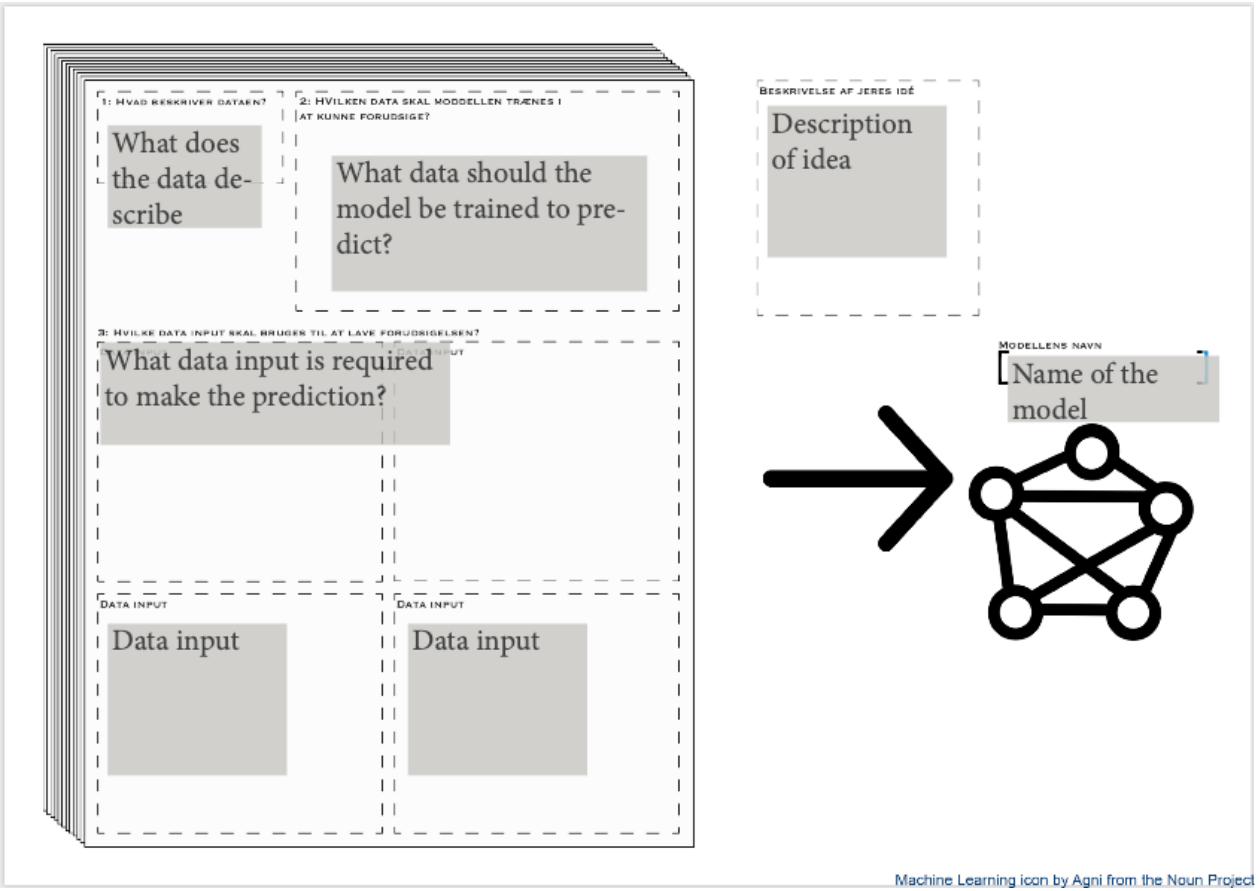
Dindler, C., Smith, R., & Iversen, O. S. (2020). Computational empowerment: participatory design in education. *CoDesign*, *16*(1), 66-80.

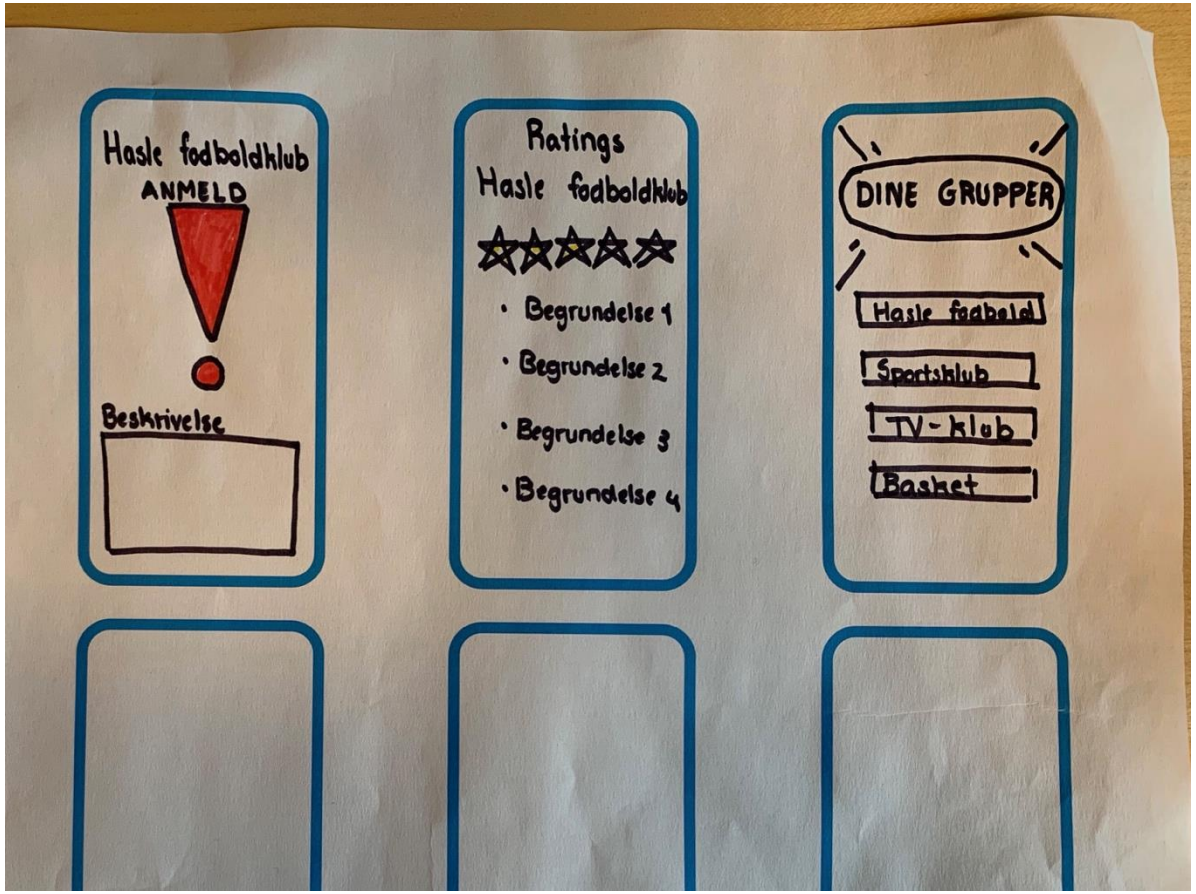
Machine learning ethics cards workshop



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

Bilstrup et al. 2020. Staging Reflections on Ethical Dilemmas in Machine Learning: A Card-Based Design Workshop for High School Students. In Proceedings of the 2020 ACM Designing Interactive Systems Conference (DIS '20).


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
Beskrivelse af jeres idé
Description of idea
Modellens navn
Name of the model
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
Sportsklub
TV-klub
Basket


a)


b


Interactions
Smart home
Data Collection
Visibility
Grandparents
Siblings

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

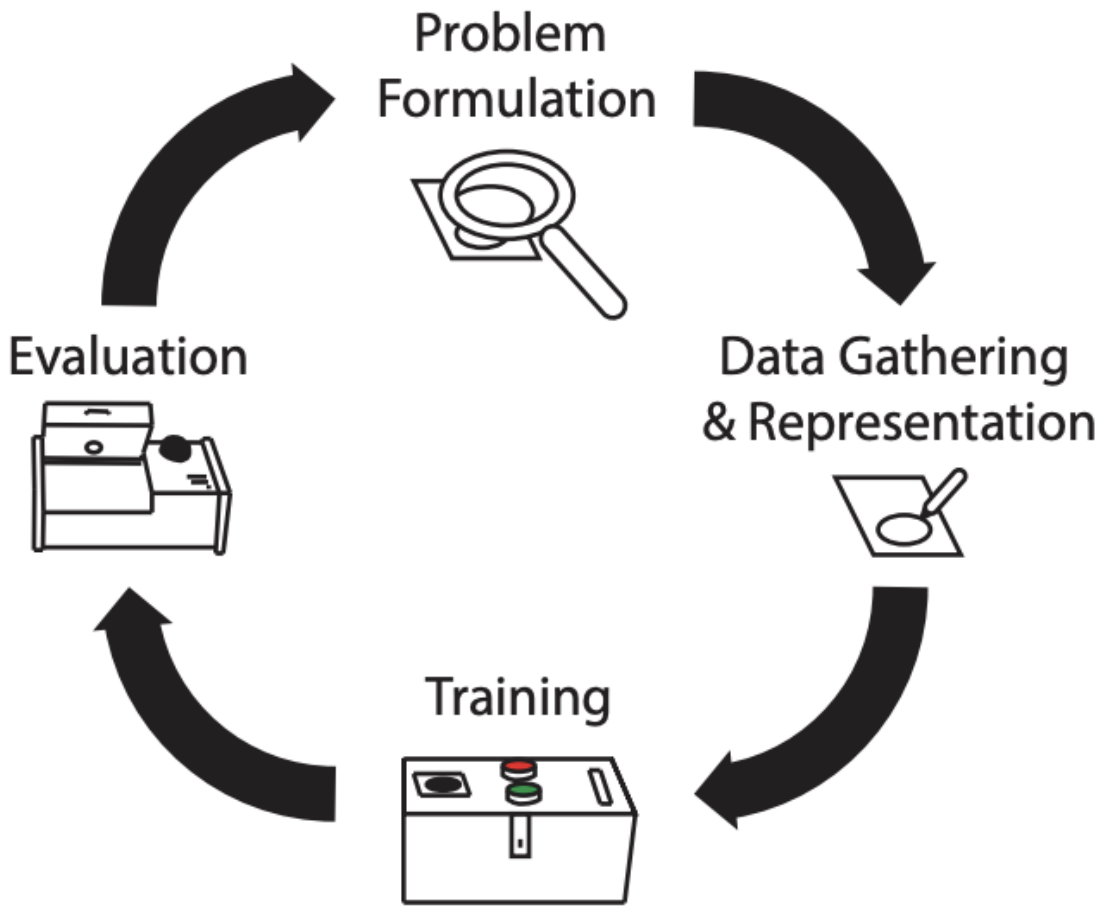
Machine learning machine

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

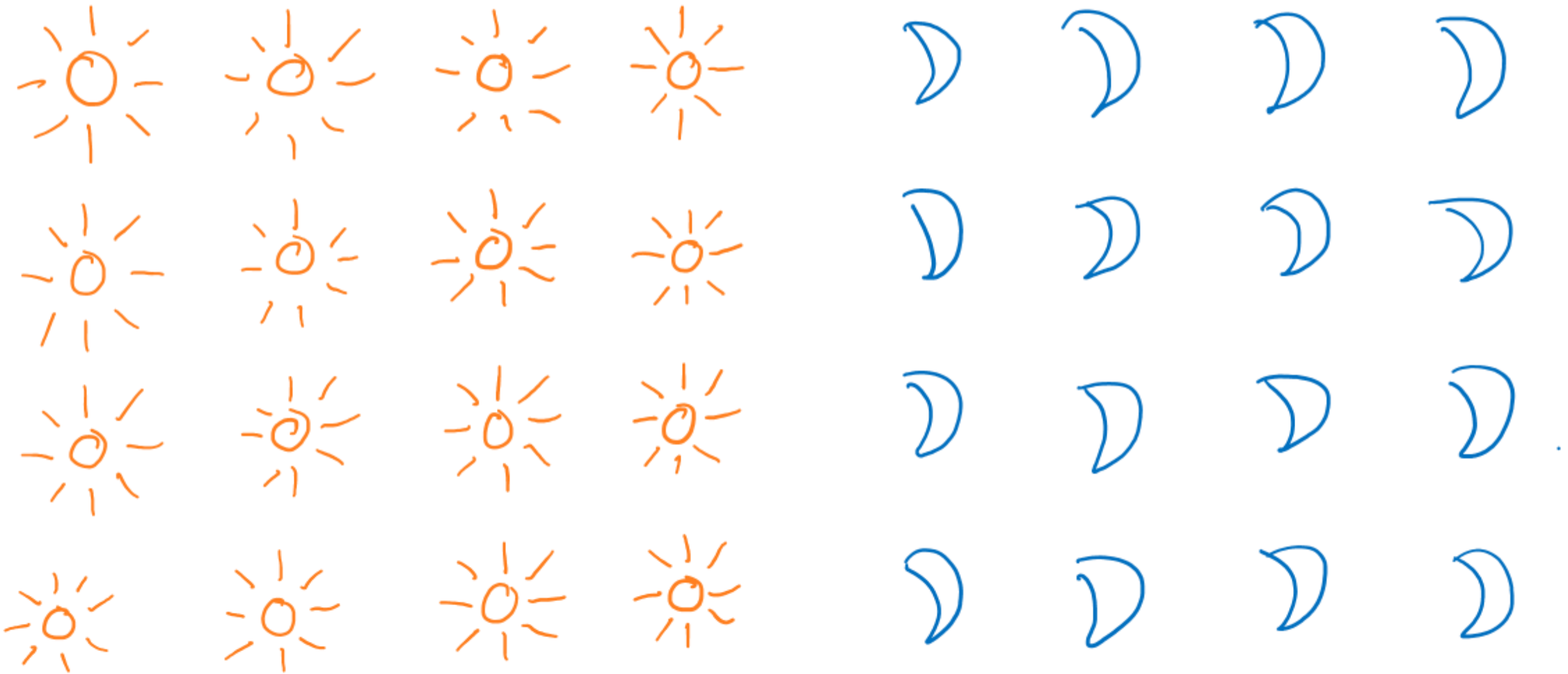

Vendinger med
overført betydning

Design rationale

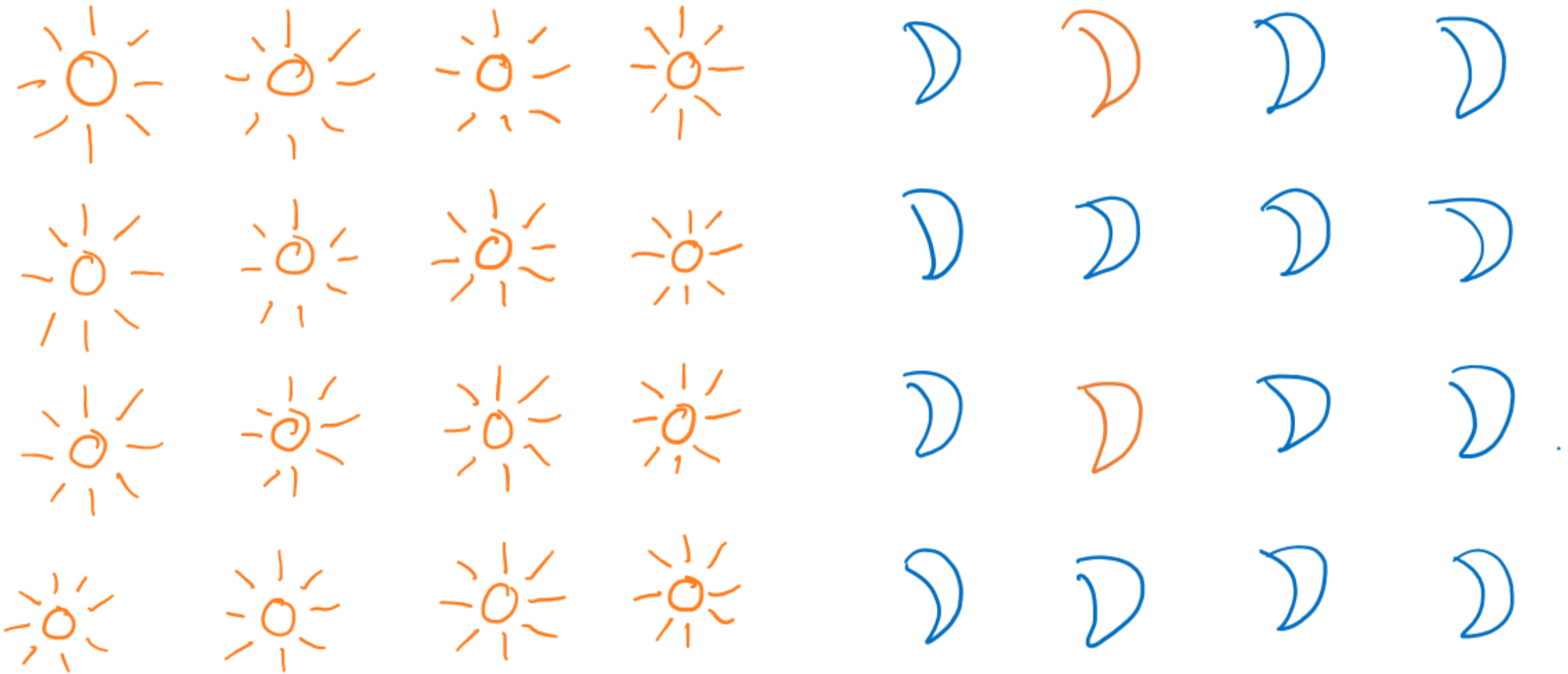
- Mystical boxes in the physical classroom
- Low floor
- Experiment and iterate to explore the boxes functionality
- Powerfull tools → slow interaction



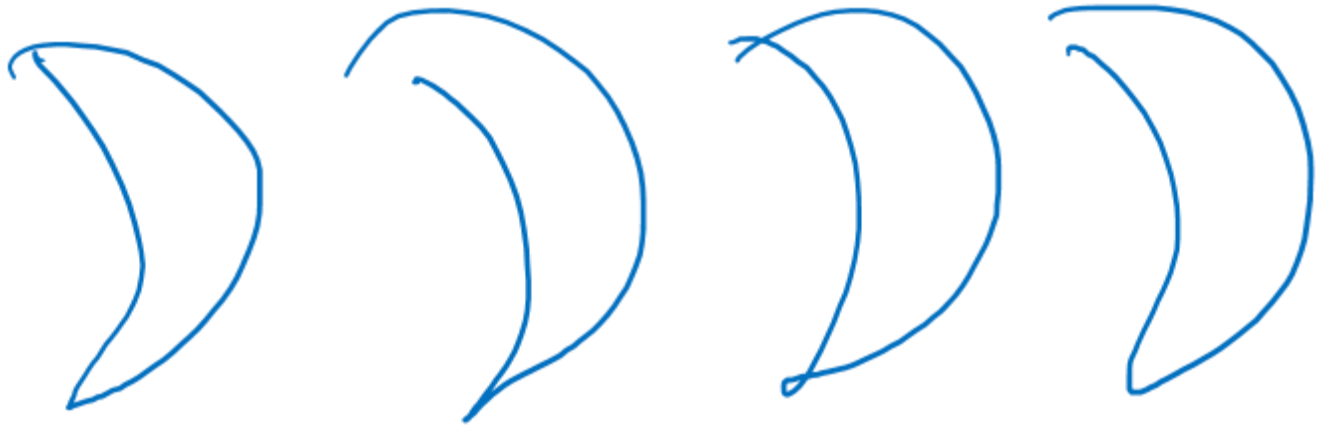
Unintended Biases



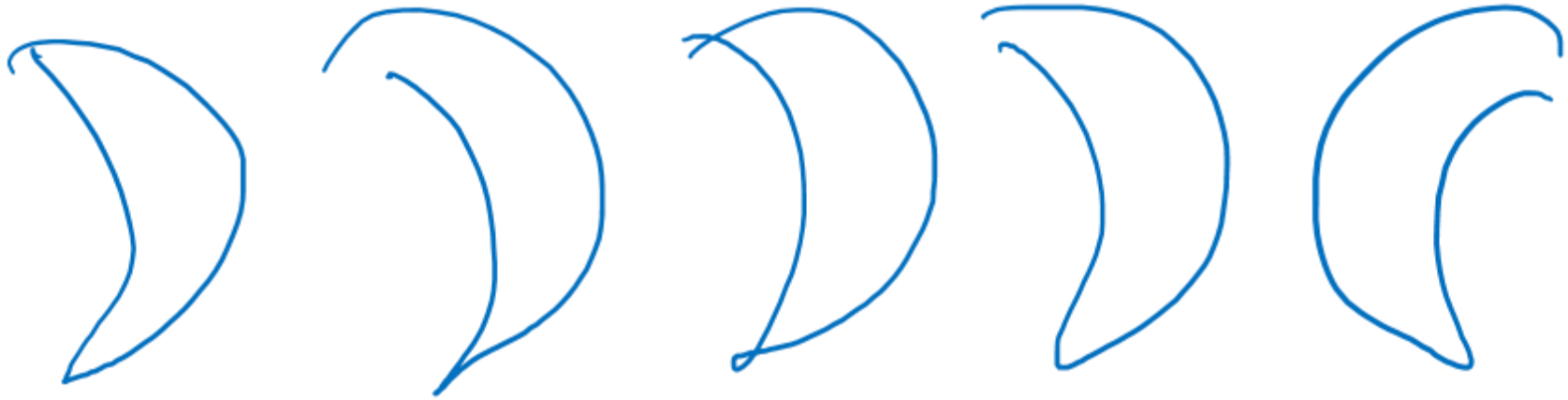
Unintended Biases



Data Representativeness



Data Representativeness

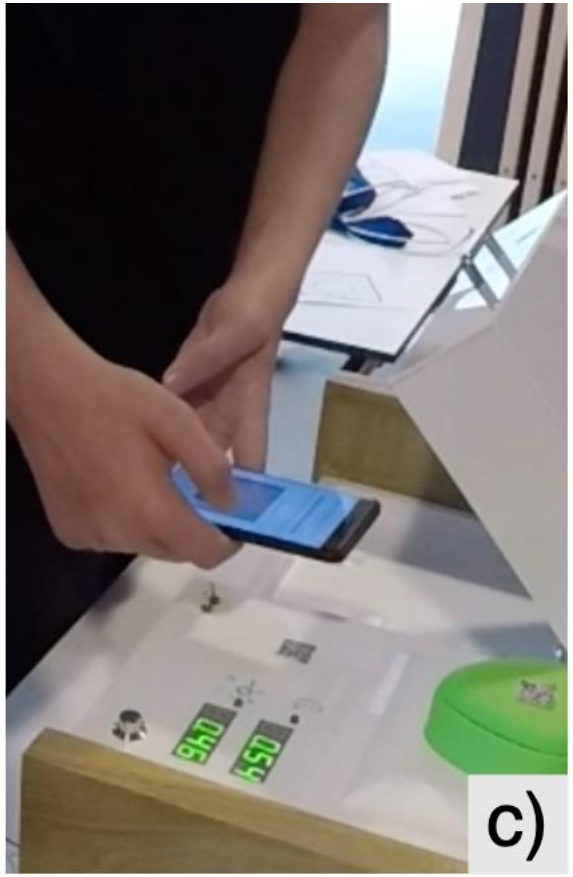


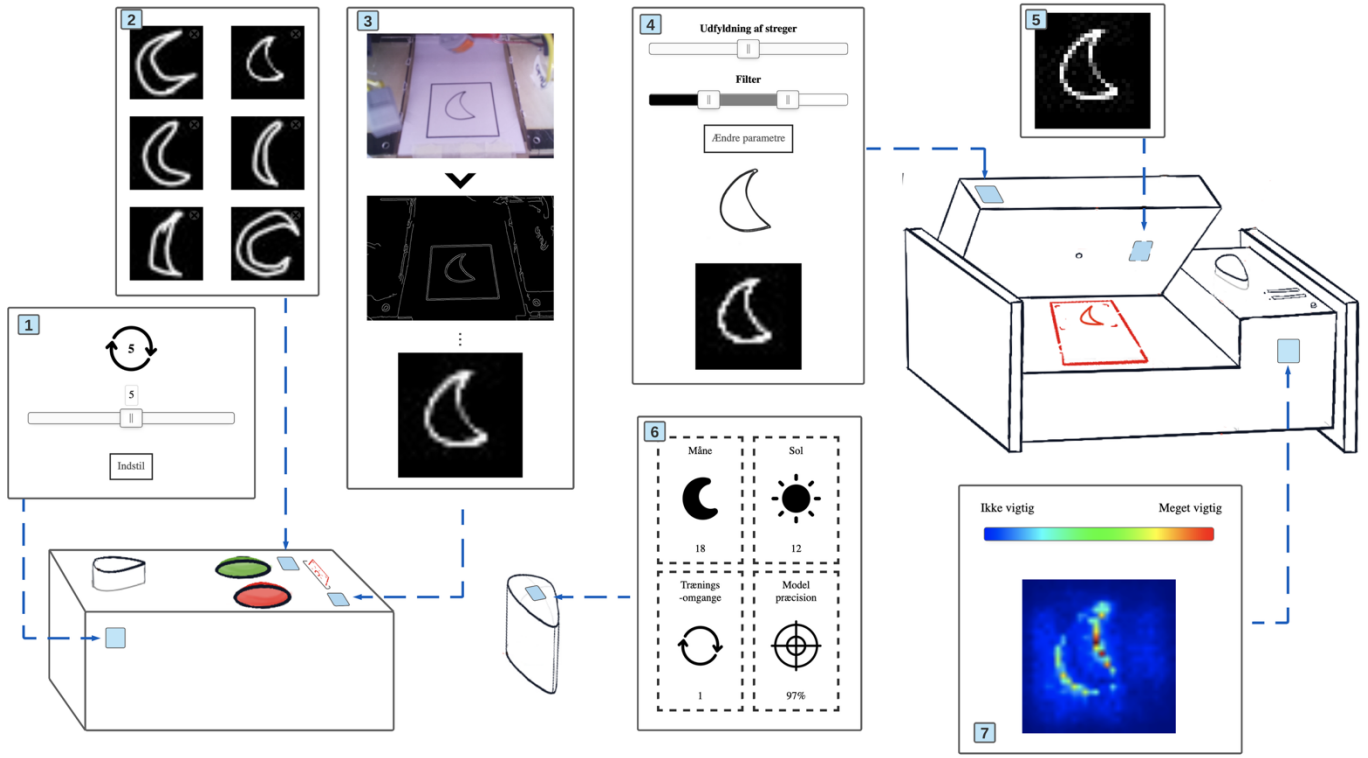
Limitations

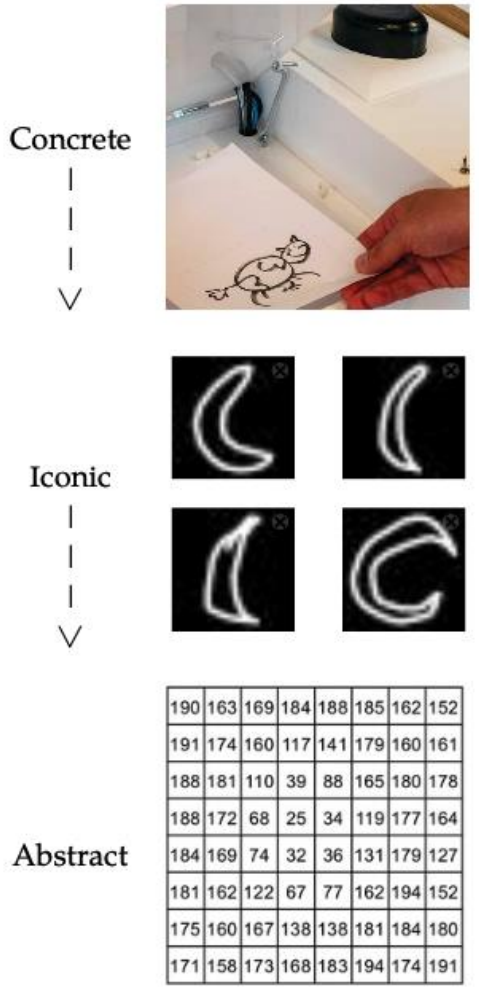
Students found it difficult to relate these experiences to the ML systems they meet in their own lives

Became a *‘dance around black boxes’*

Opening the black box

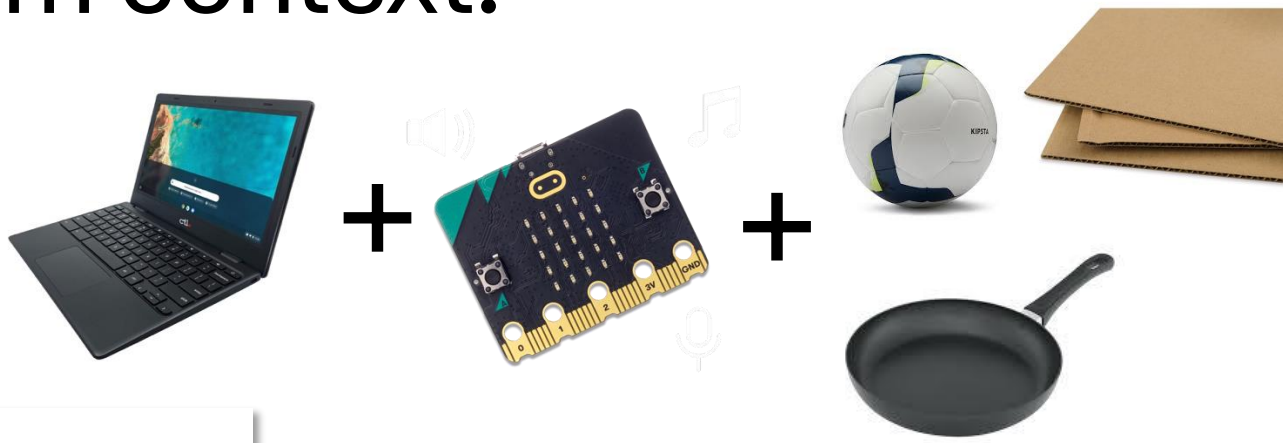


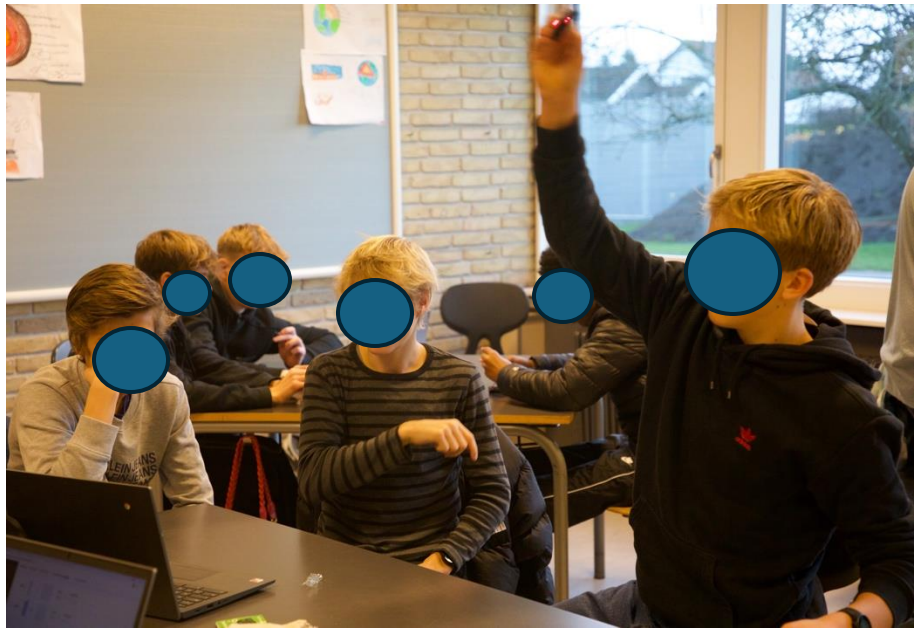




[Bilstrup et al., The best of both worlds: Designing a tiered hybrid interface for teaching machine learning in K-9 education, NordiCHI 2022]

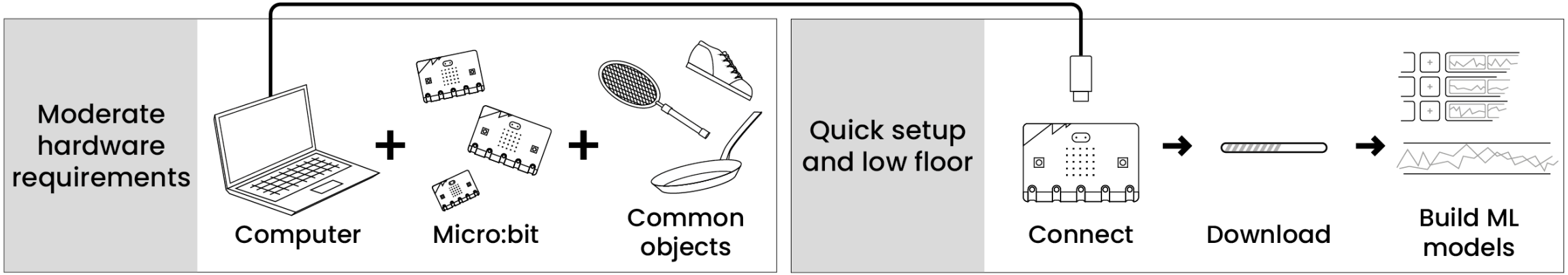
Design for the classroom context: ml-machine.org/

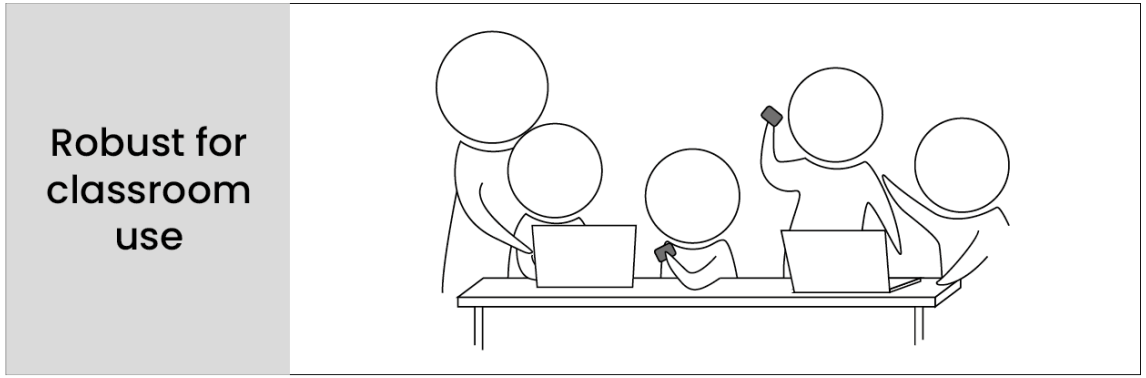




[Bilstrup et al., Opportunities and Challenges of Teaching Machine Learning as a Design Material with the micro:bit, NordiCHI 2022]

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



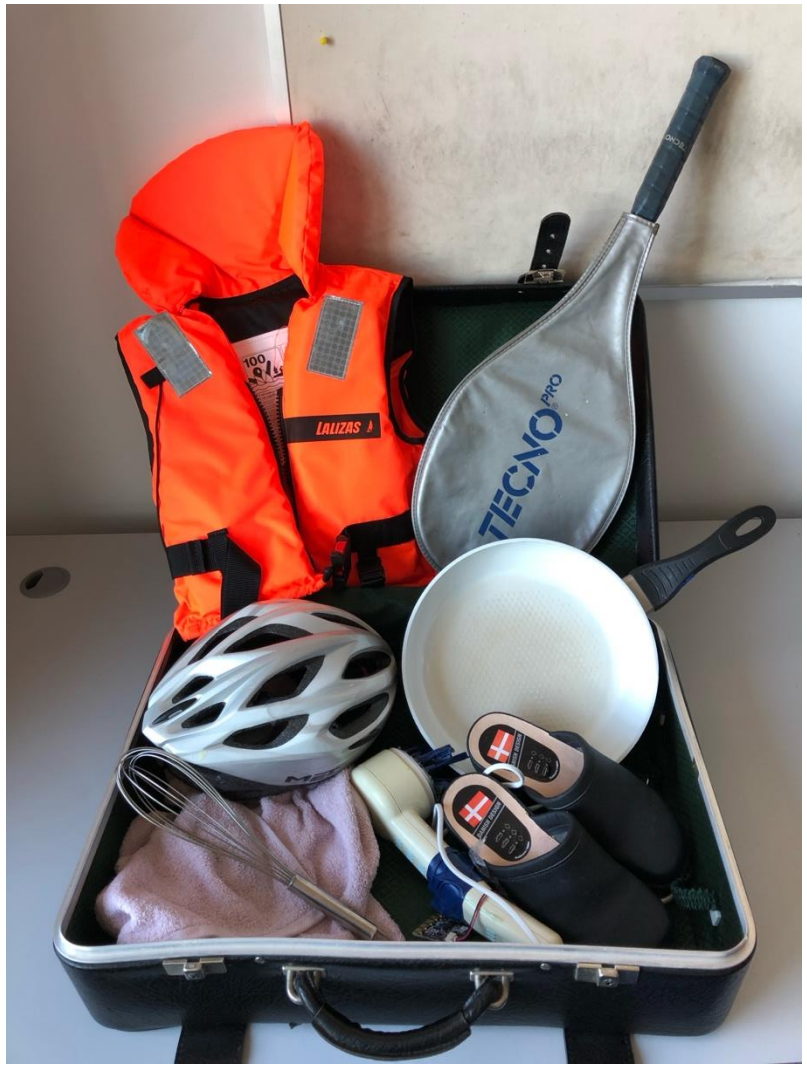


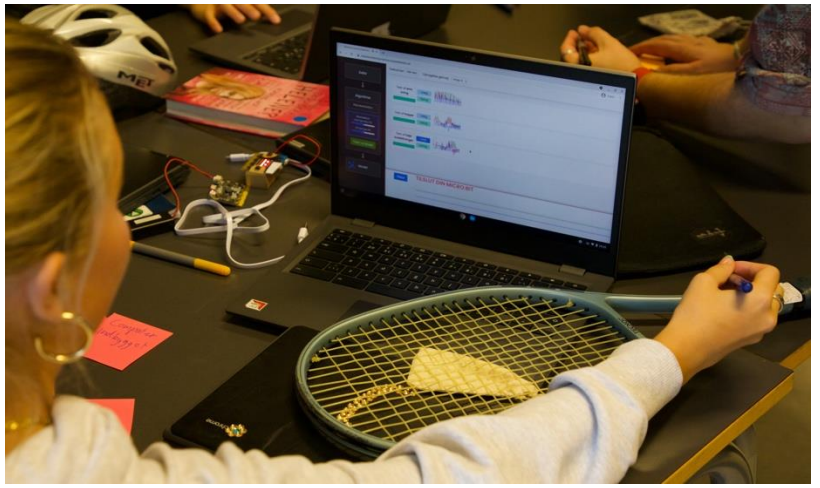
[Bilstrup et al., The ML-Machine Toolkit: Empowering Teachers and Education Professionals to Explore Embodied Approaches to Teaching Machine Learning, DIS 2025]

Demo

ml-machine.org/

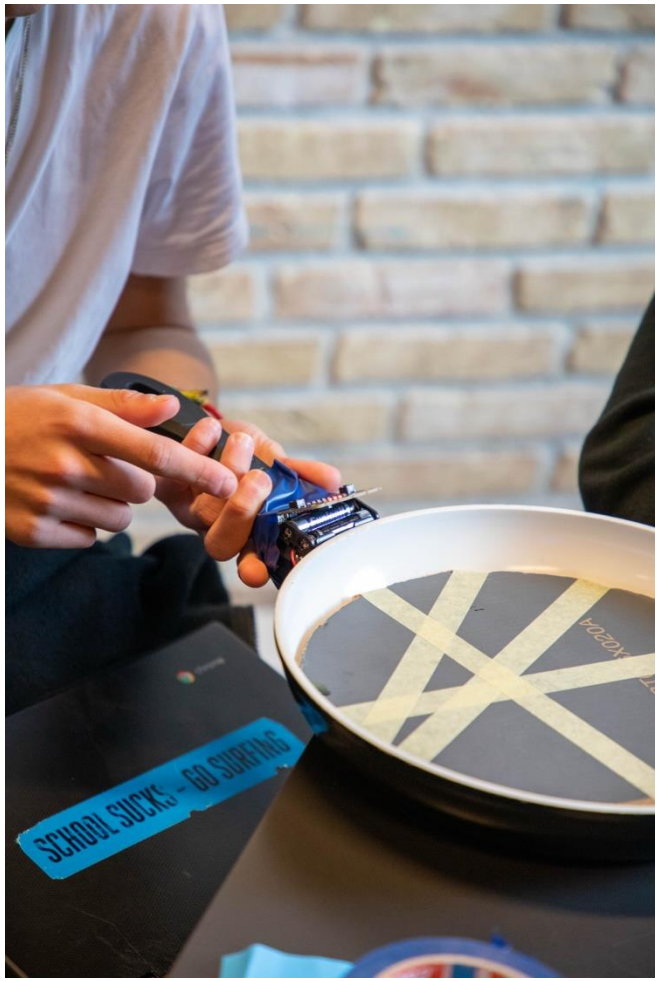
Machine learning as a design material



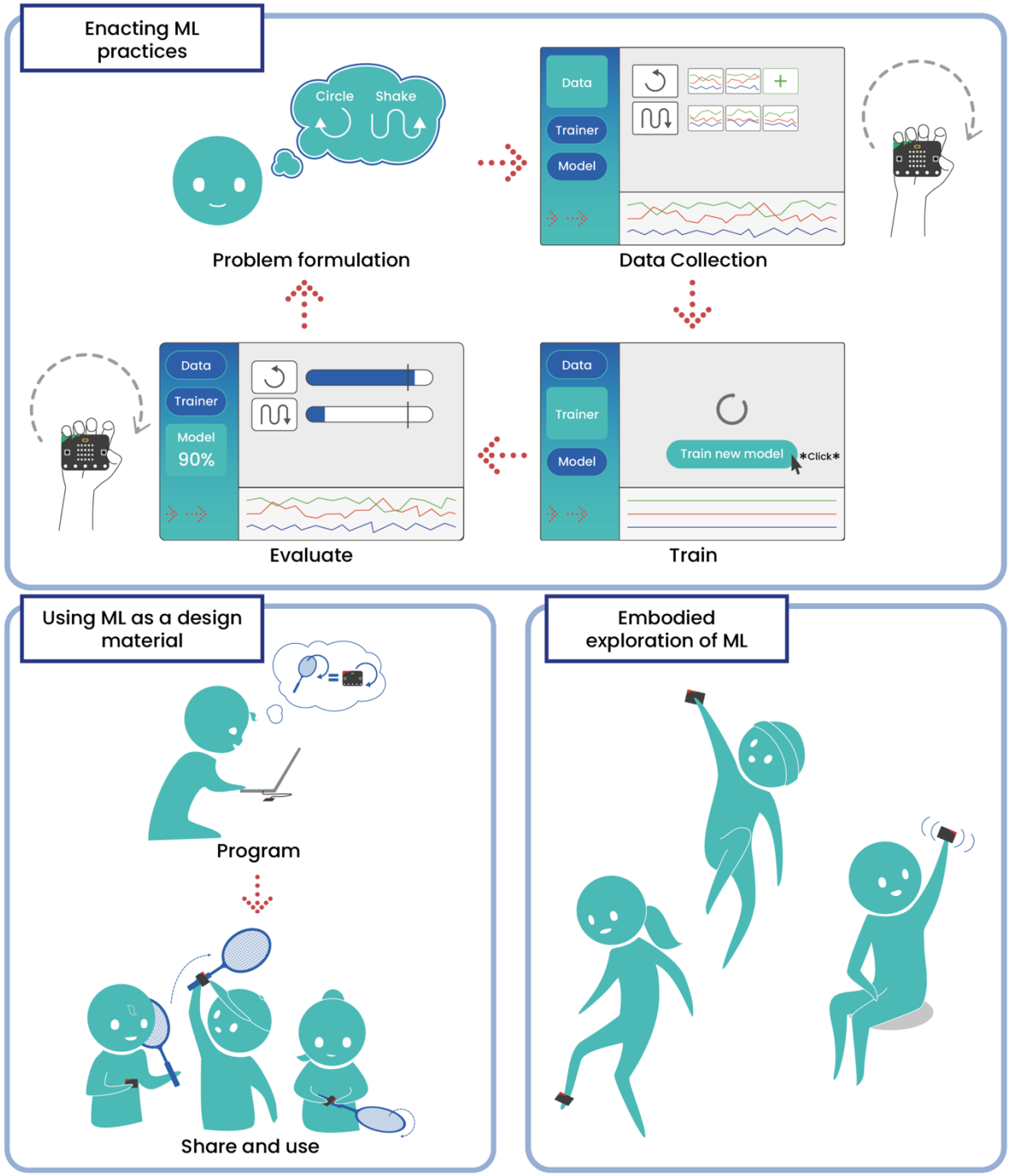


Fuijips

The future is **now**


SCHOOL SUCKS - GO SURFING

Learning about machine learning through embodied interaction



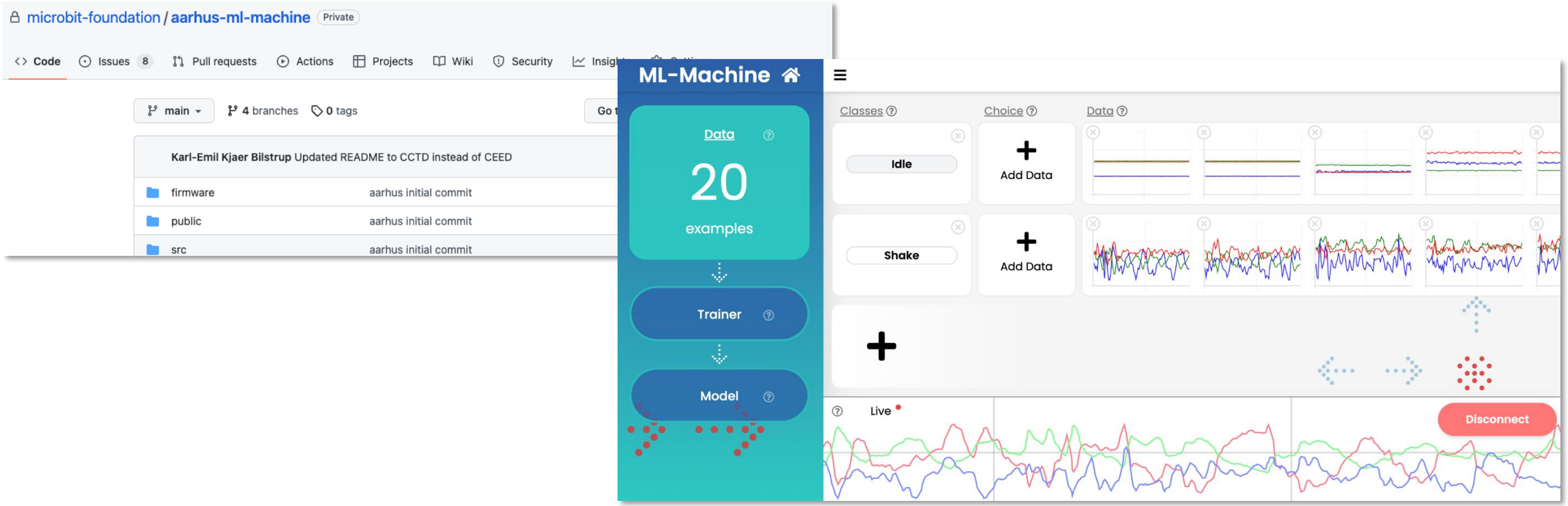
[Bilstrup et al., The ML-Machine Toolkit: Empowering Teachers and Education Professionals to Explore Embodied Approaches to Teaching Machine Learning, DIS 2025]

Working with multiple representations and abstractions

Finding patterns in accelerometer data

Train ML model to recognize bodily activity

Redesign a physical artefact with ML

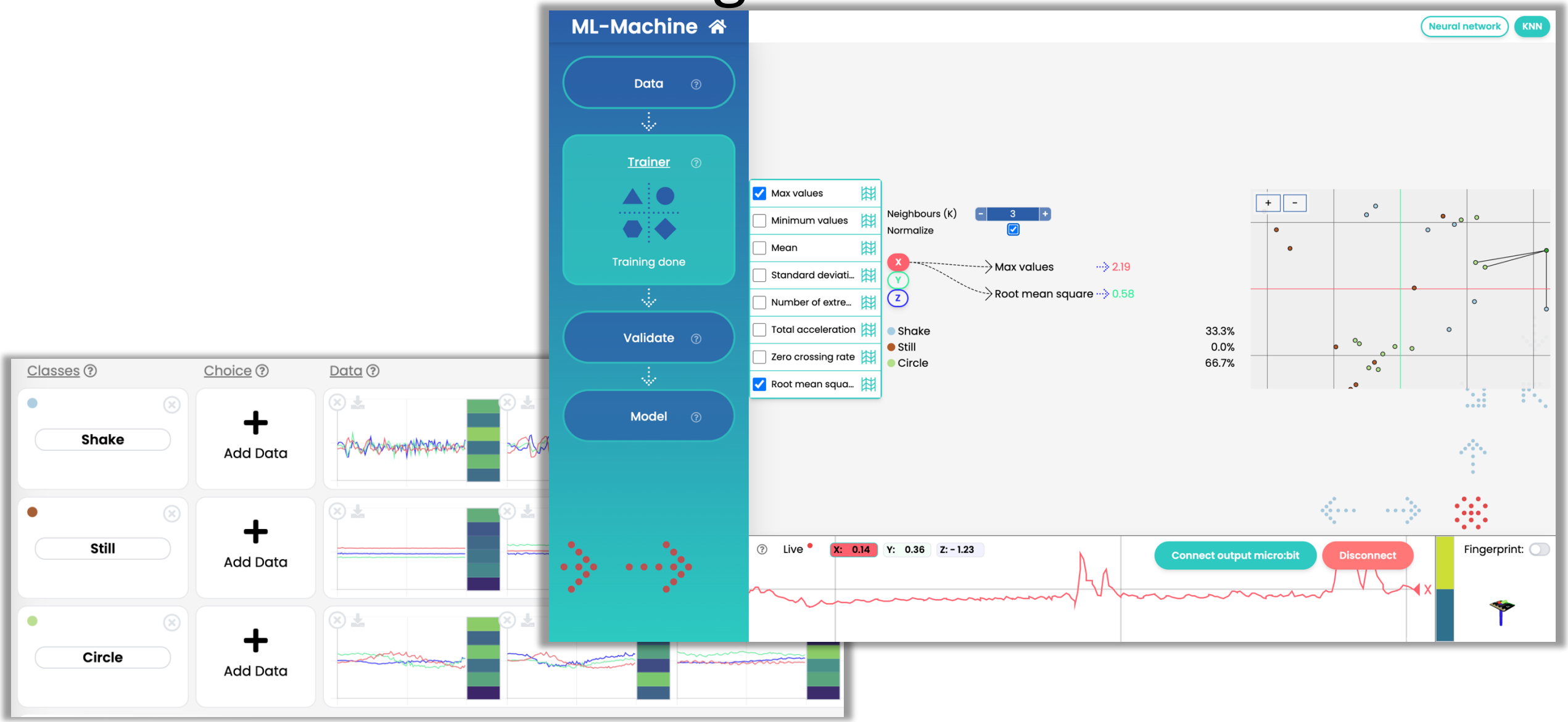


ml-machine.org/

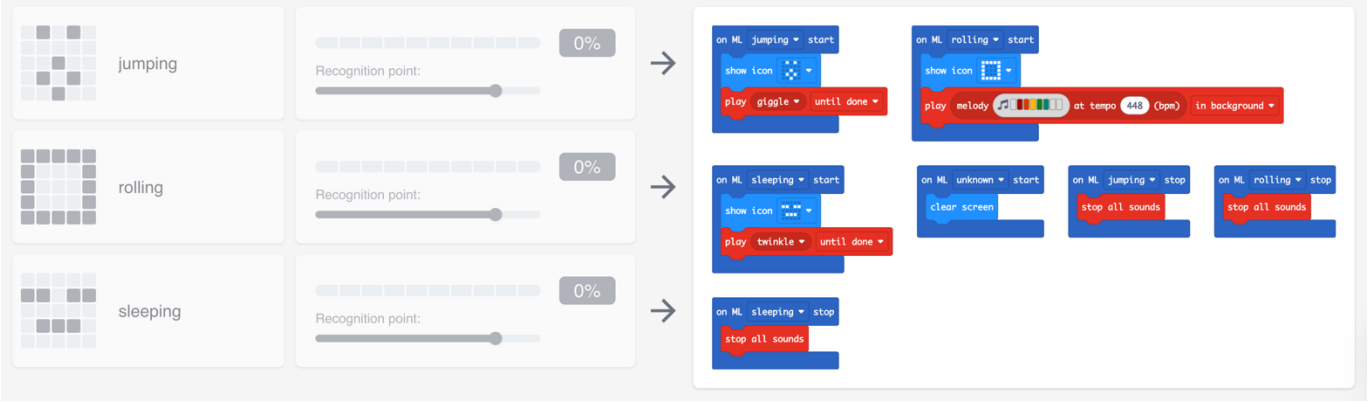
math.ml-machine.org/ (in development)

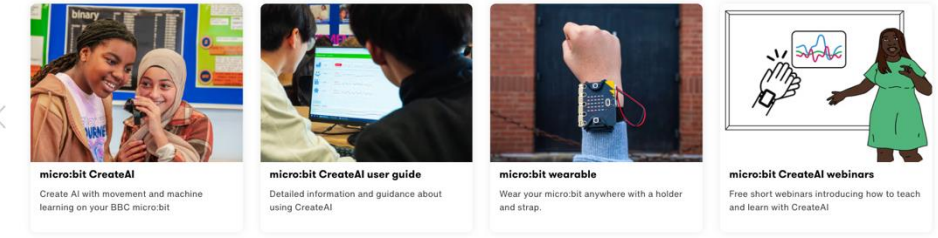
github.com/microbit-foundation/aarhus-ml-machine/

math.ml-machine.org/



createai.microbit.org/





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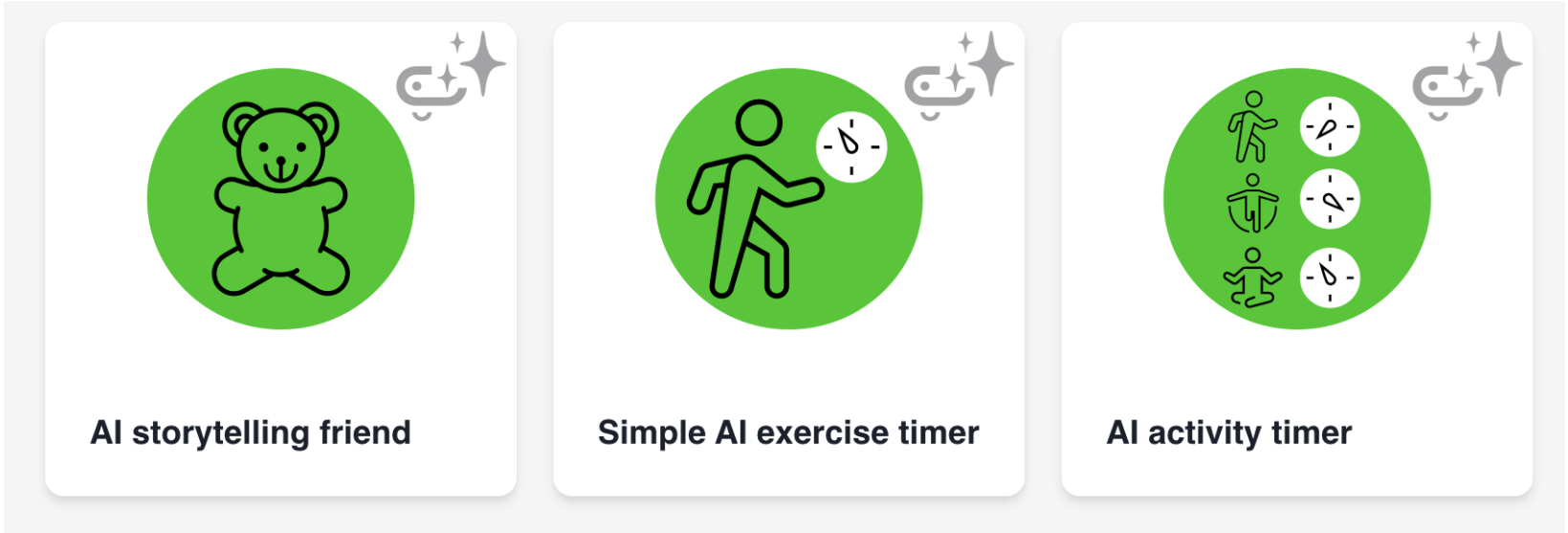
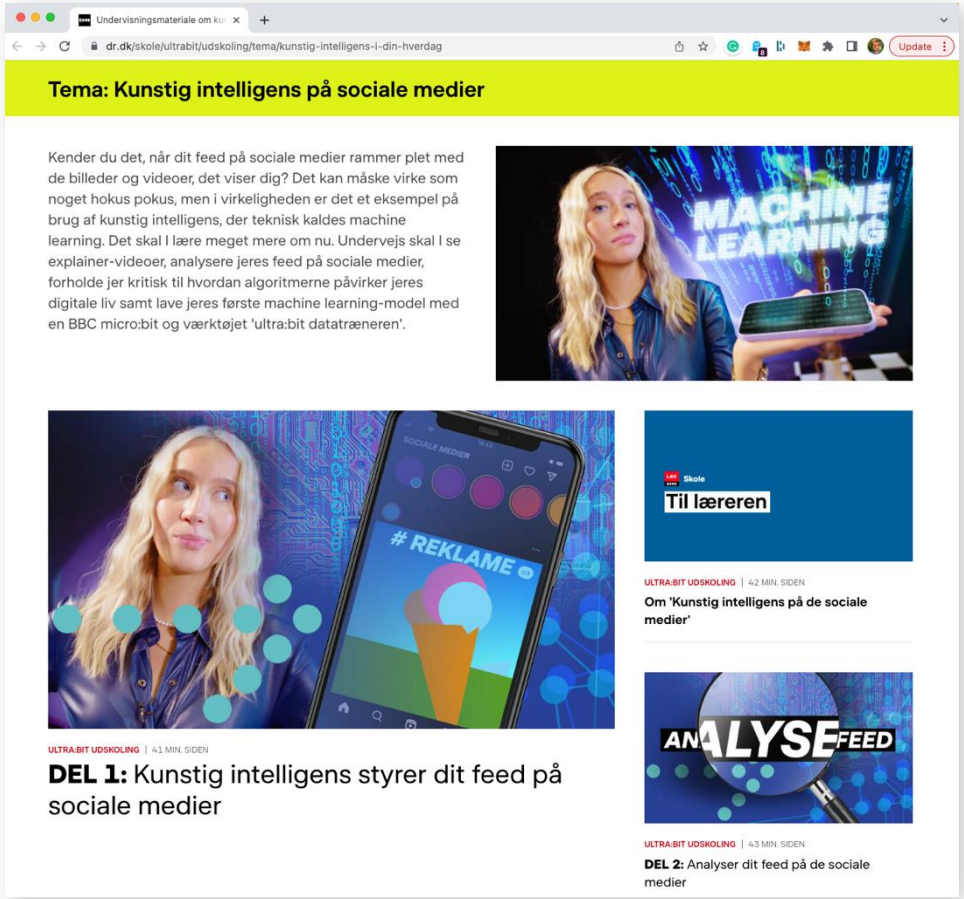
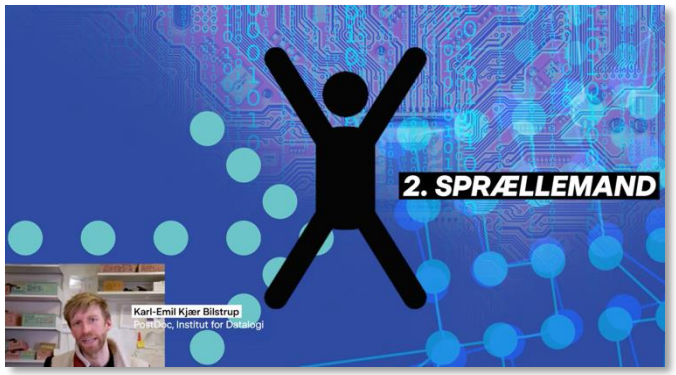


Building educational material around the embodied activites





LÆR
DR

[Bilstrup et al., ml-machine.org: Infrastructuring a Research Product to Disseminate AI Literacy in Education, CHI 2024]

Unintentional bias

Undesired content on social media

Data Representativeness

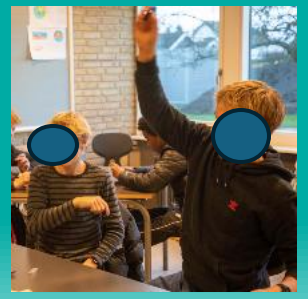
Self-driving cars

Google tags photos incorrectly

Enacting key challenges in developing and implementing machine learning systems

Unintended biases

Machine learnng machine



ml-machine.org

Data representativeness

ml-machine.org

Critical data intervention

Impact of parameters

Machine learnng machine

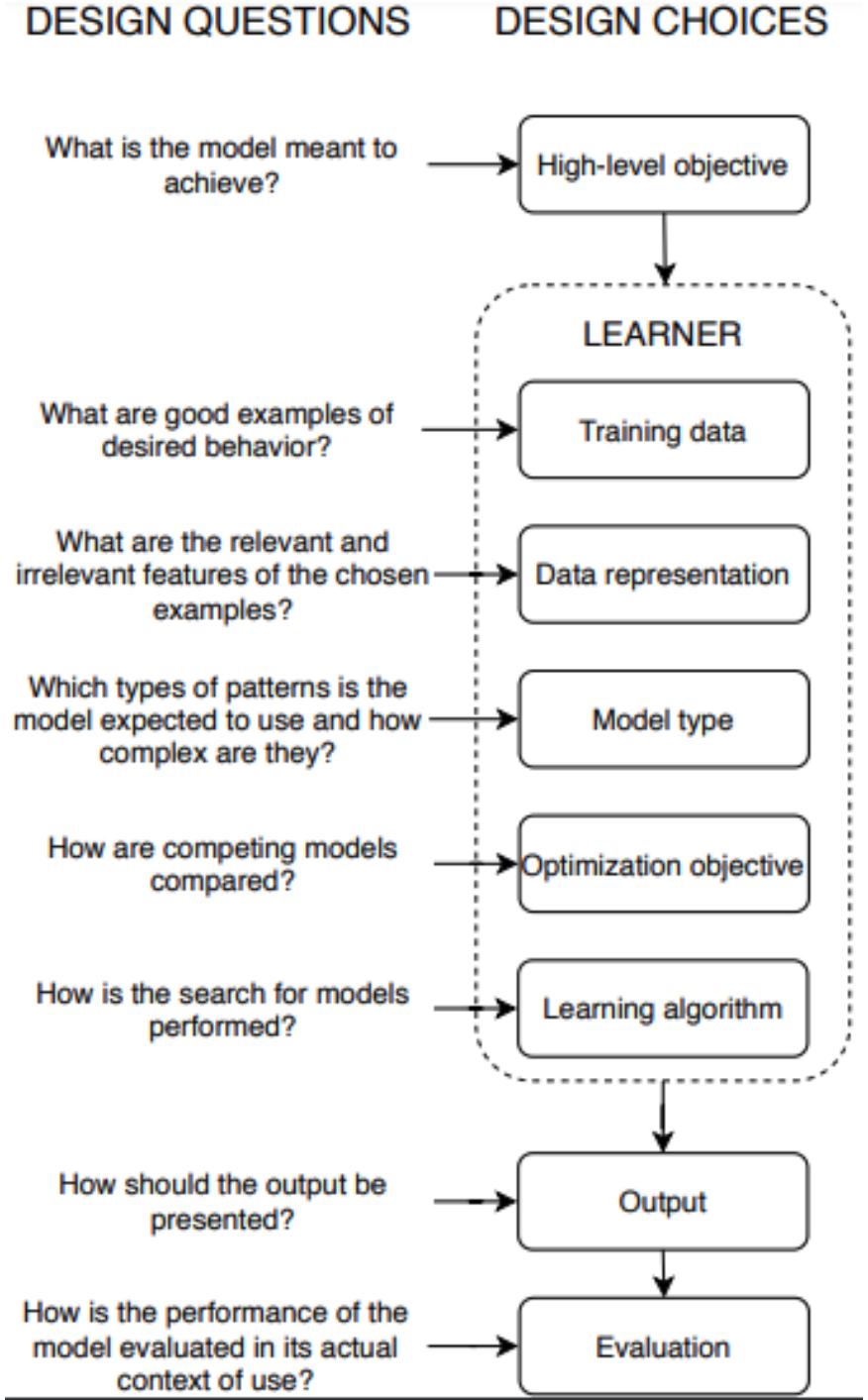
Critical data intervention

Karl-Emil Bilstrup. 2023. Embodied Computational Empowerment: Designing Educational Tools for Critical Reflection on Computational Technologies

from

DEMO → DESIGN

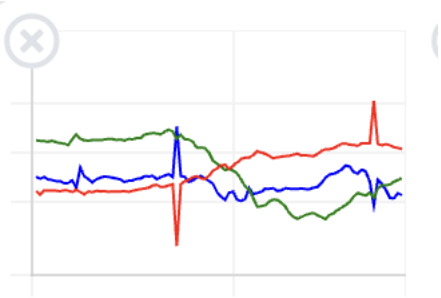
in teaching machine learning



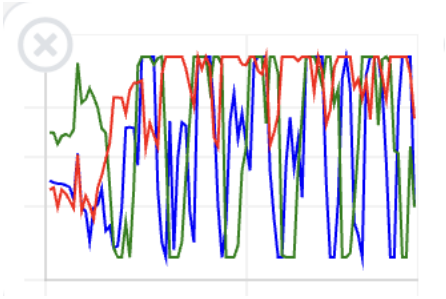
[Bilstrup et al., From Demo to Design in Teaching Machine Learning, FAccT 2022]

How does this relate to chatbots?

Machine learning: Predict the next symbol



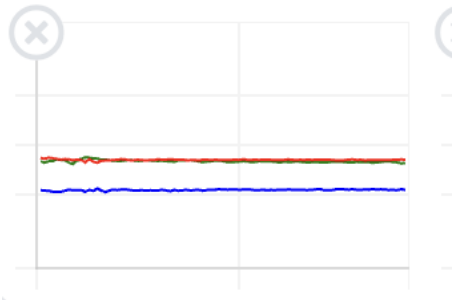
Triangle



Shake

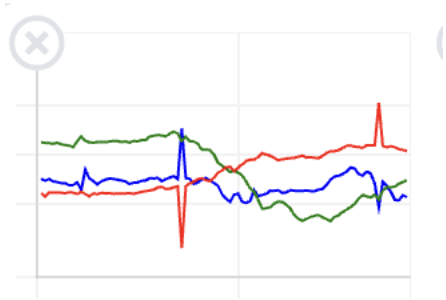
What is the next word in this…

sentence

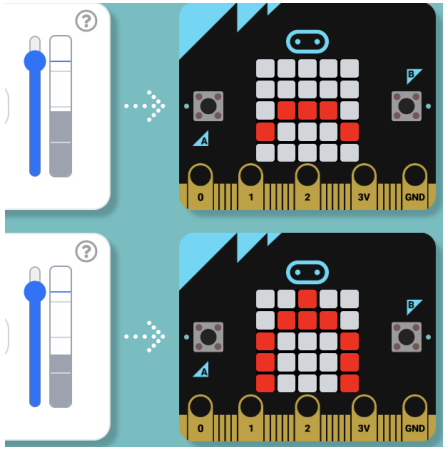


Inactive

How do we choose the next word?



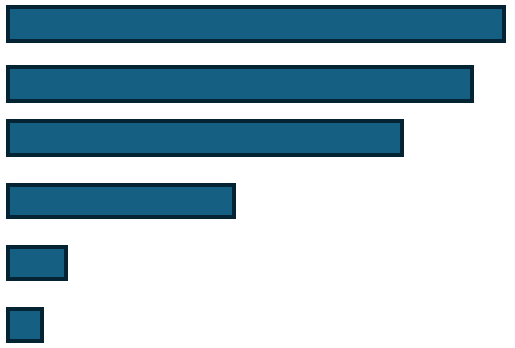
Triangle
Shake
Still



What is the next word in this...

sentence
book
novel
compound
washing machine
or
...

Probability



Generating new sentences with our model 

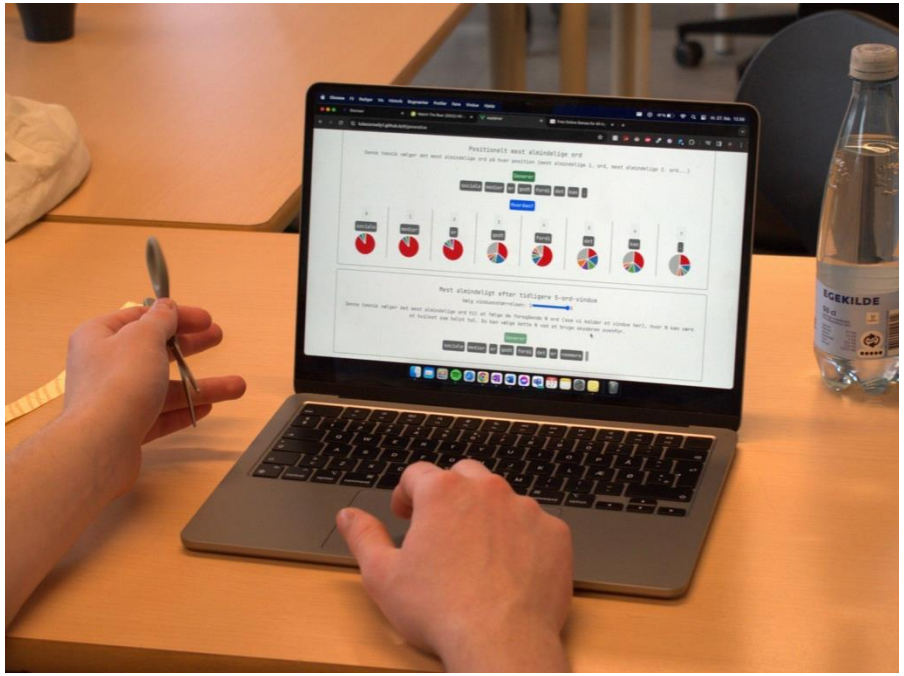
What is the next word in this →  → book

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?



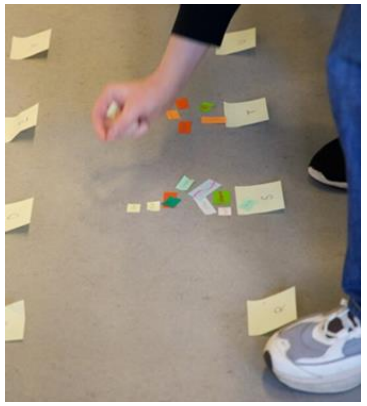
The Engine Room

maskinrummet.github.io/#/en

Luke John Connelly

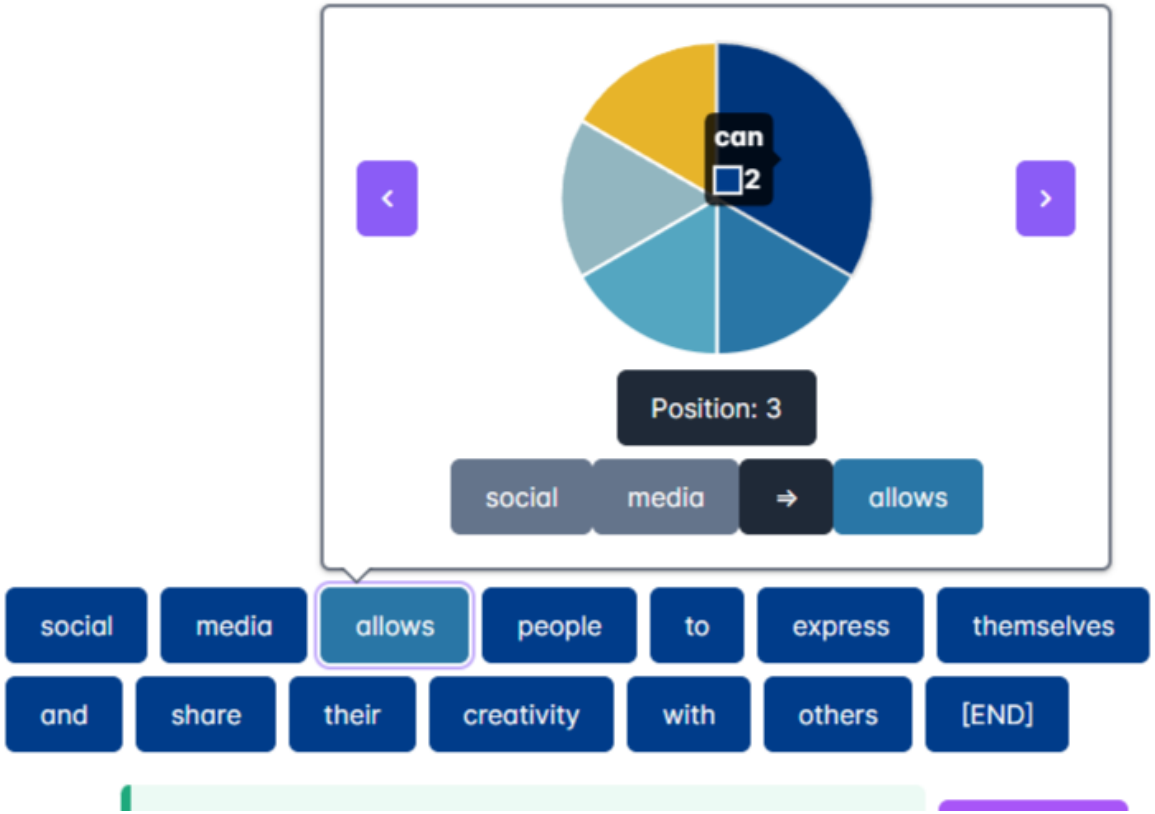
Connelly et al. 2025. Beyond LLMs as Black Boxes: Activities and an Educational Tool Supporting Unplugged and Digital AI Learning Activities for K-12 Classrooms. In Adjunct Proceedings of the Sixth Decennial Aarhus Conference: Computing X Crisis (AAR Adjunct '25).

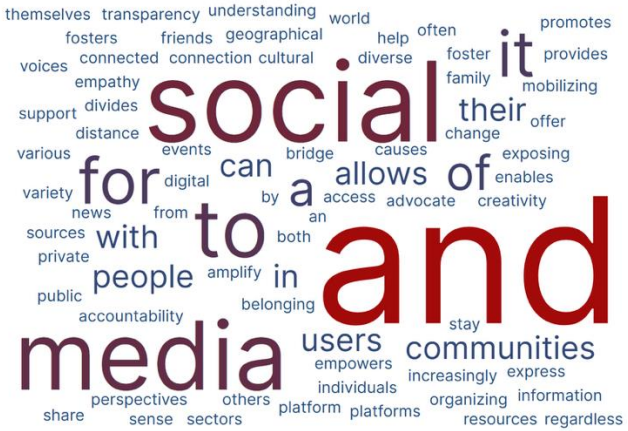
Teaching natural language processing (NLP)

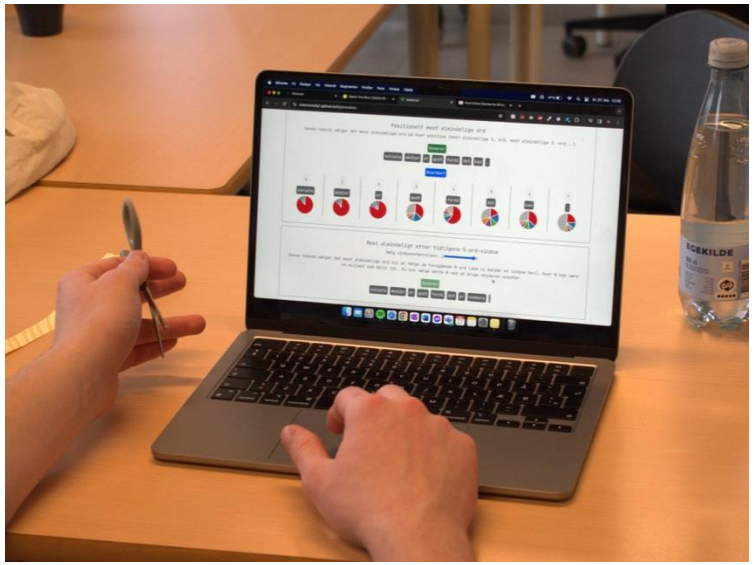


Teaching natural language processing (NLP)

maskinrummet.github.io/#/en







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