PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

Oliver Kastner-Hauler, Bernhard Standl, Barbara Sabitzer, Zsolt Lavicza

Developing Design Principles for Computational Thinking Learning Environments

Pathways into Practice with Physical Computing

PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

Computational Thinking (CT) in curricula worldwide

- Future jobs require education in CT and problem-solving
  - CT uses tools and techniques from Computer Science (CS)
  - extending beyond CS, various disciplines (STEM/STEAM)
- Basic Digital Education (BDE) subject since 2022(2018) in Austria
  - CT, media and computer literacy
  - Grades 5 to 8 (10 - 14 years old)
- Teachers for BDE
  - Some in-service training options, no formal education
  - Feel “not well-prepared”, struggle with new subject and materials
  - CT omitted, focus on media and computer literacy

PH NÖ PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

Design Principles for CT Learning Environments

- Enable CT with principled approach
  - Practice-oriented handbook
  - Ongoing Design-based research (DBR)
- 3 Learning Environments (LEs) for CT education
  - Guide for teachers and students
  - No prior CS knowledge needed
- Design Principles
  - Create, enrich, and evaluate material for CT learning
  - Practical guiding principles, learning-by-doing with LEs
  - Lower entry barriers and missing bridge in BDE (CT, media & computer)

PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

Background (1)

Ongoing Definition of CT

- Selby and Woollard (2013)
- Palts and Pedaste (2022)

Assessments of CT

- Tang et al. (2020)
- Weintrop et al. (2021)

Problem-Solving Congruence

Labusch et al. (2019)

Nouri et al. (2020)

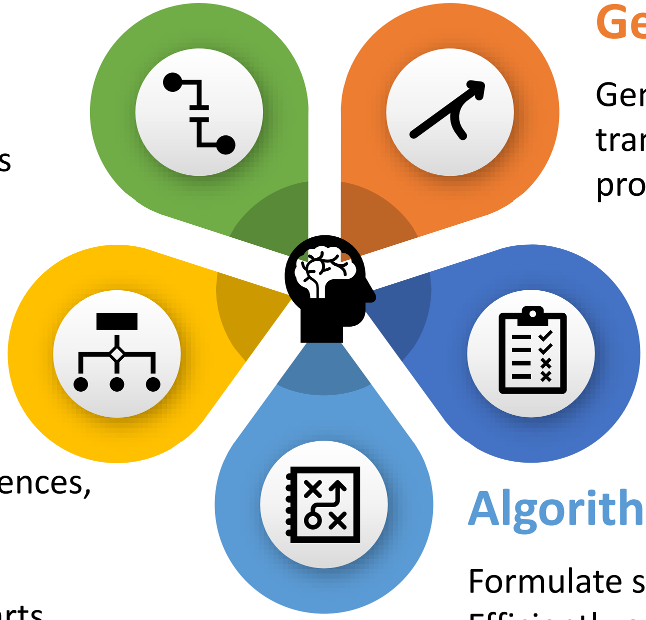
CT – A Thought Process (Li et. al, 2020)

Decomposition

Breaking down problems into smaller, easier manageable parts

Generalization

Generalize solution and transfer to other, similar problems



Evaluation

Test and debug
Evaluate, and predict outcome of solution

Abstraction

Look for repeating sequences, and similarities
Recognise patterns
Remove unnecessary parts

Algorithmic Thinking

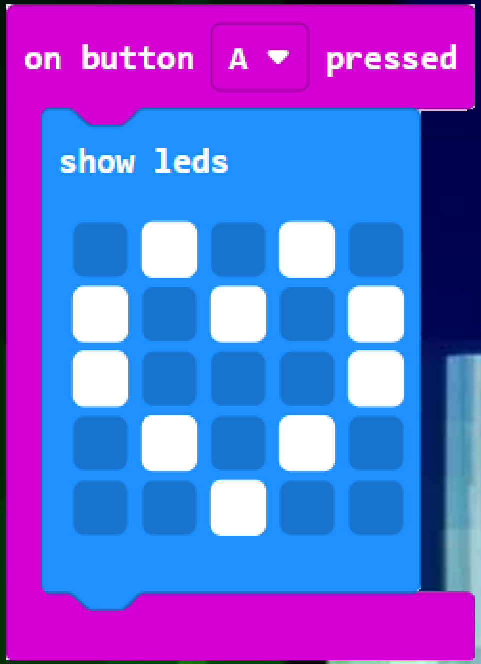
Formulate step-by-step solution
Efficiently and effectively use ressources, and automate solution

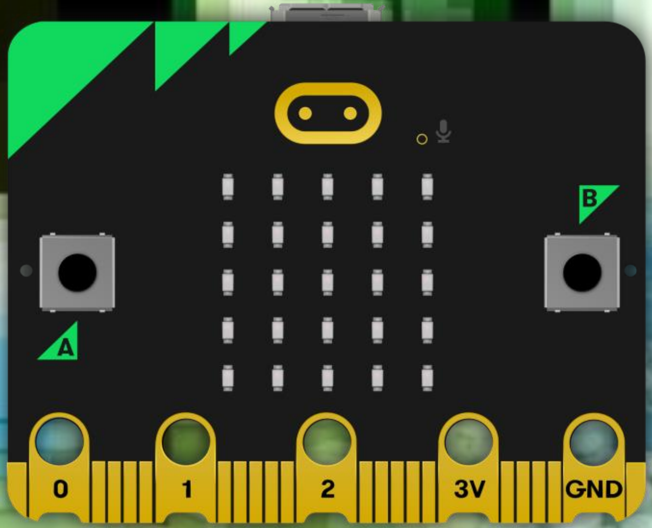
Figure: Adapted from Selby & Woollard (2013) with extensions by Kastner-Hauler (2021).

© Copyright PresentationGO.com – The free PowerPoint and Google Slides template library

Background (2)

- Block-Based Programming
  - Easy code construction for lower grades
  - Snap-together blocks like building toy house
- Physical Computing
  - Create tangible real-world products
  - Artifacts manifest mental concepts
  - Visualize thinking process





PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

Background (3)

- Inquiry-Based Learning (IBL)

  Operationalized by 5E cycle instructional model

  Engage, explore, explain, elaborate, and evaluate

  Flexibility for teachers to tailor individual student learning

  Textbook interactive elements

  Spoiler links to actively uncover additional information (Wiki)

PH NÖ PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

Methods: Development of Handbook Principles

3 LEs - Cycles of Design-based Research (McKenney and Reeves, 2013, 2018)

01

Flipped Adaption of OER

2021

Split Making & Coding

02

Combined effects physical + block-based

2022

Assessment with BCTt

03

CT teaching efficacy

2024

Assessment with Bebras (under review)

04

This Research Design Principles

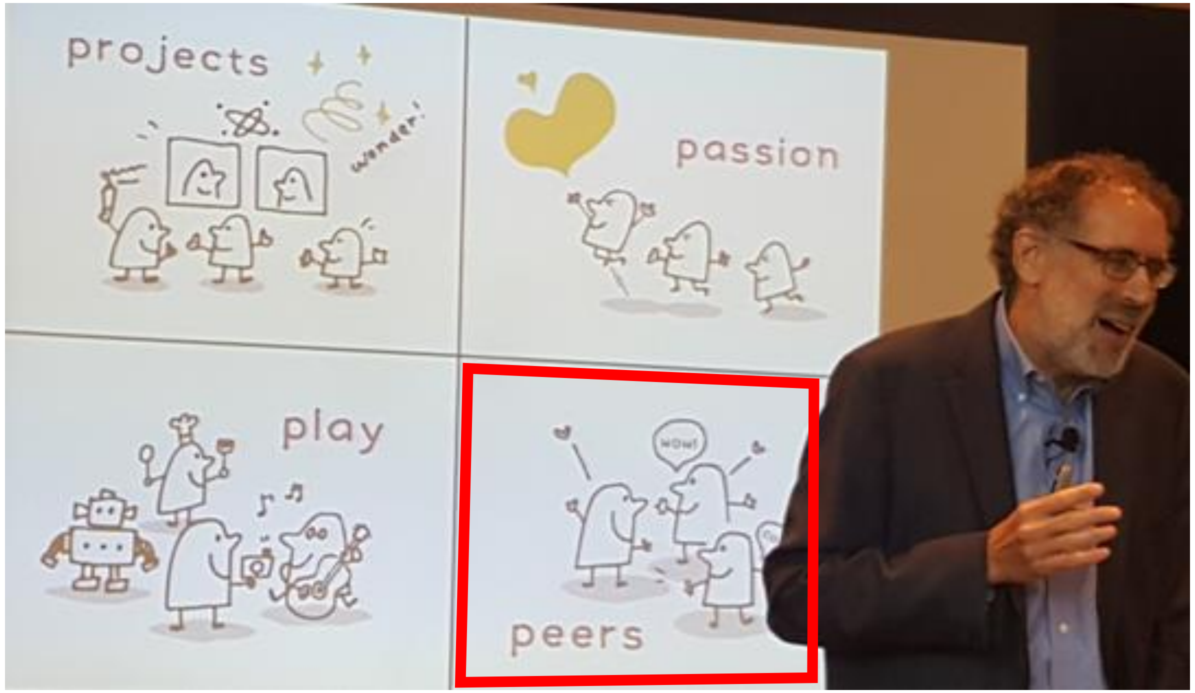
2024

© Copyright PresentationGO.com – The free PowerPoint and Google Slides template library

PÄDAGOGISCHE HOCHSCHULE
NIEDERÖSTERREICH

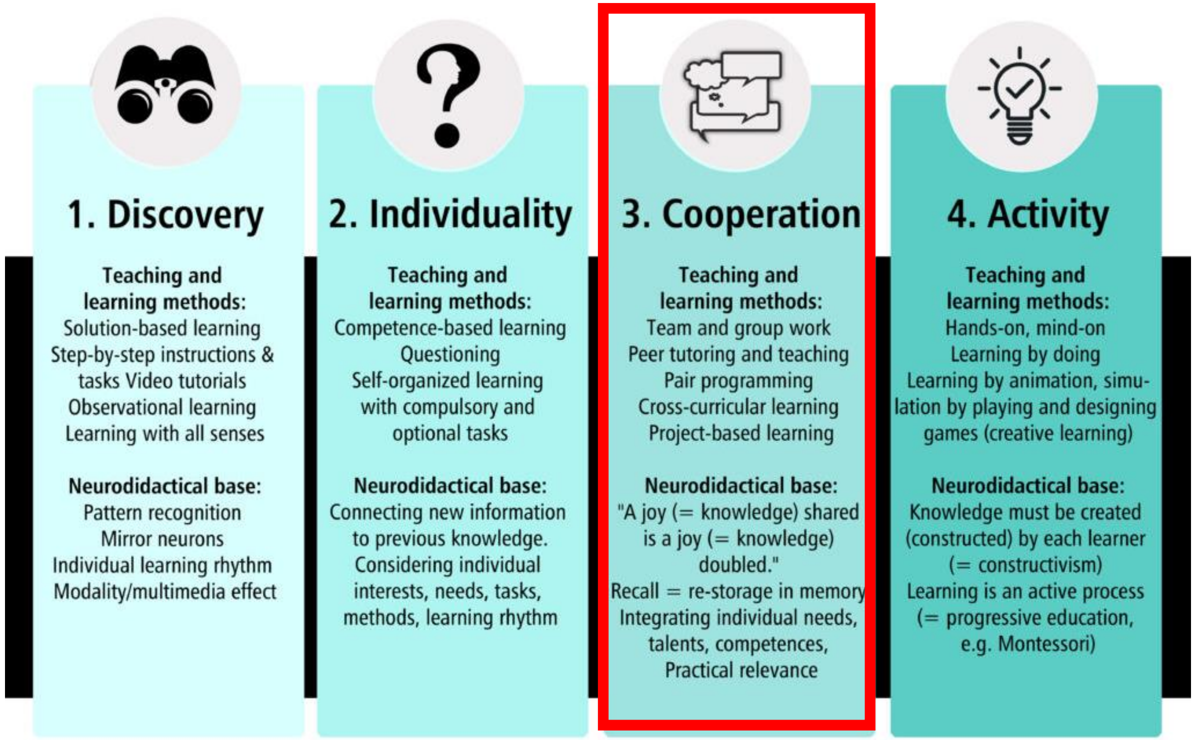
Higher Level Frameworks – Logical and Natural Progression of CT Development to Identify Action Areas for Design principles

4 Ps of Creative Learning
(Mitch Resnick, 2014)



https://scratch.by/en/about/news/mitchel_resnick_the_four_ps_of_creative_learning/

The Concept of COOL Informatics
(Sabitzer et al., 2019)



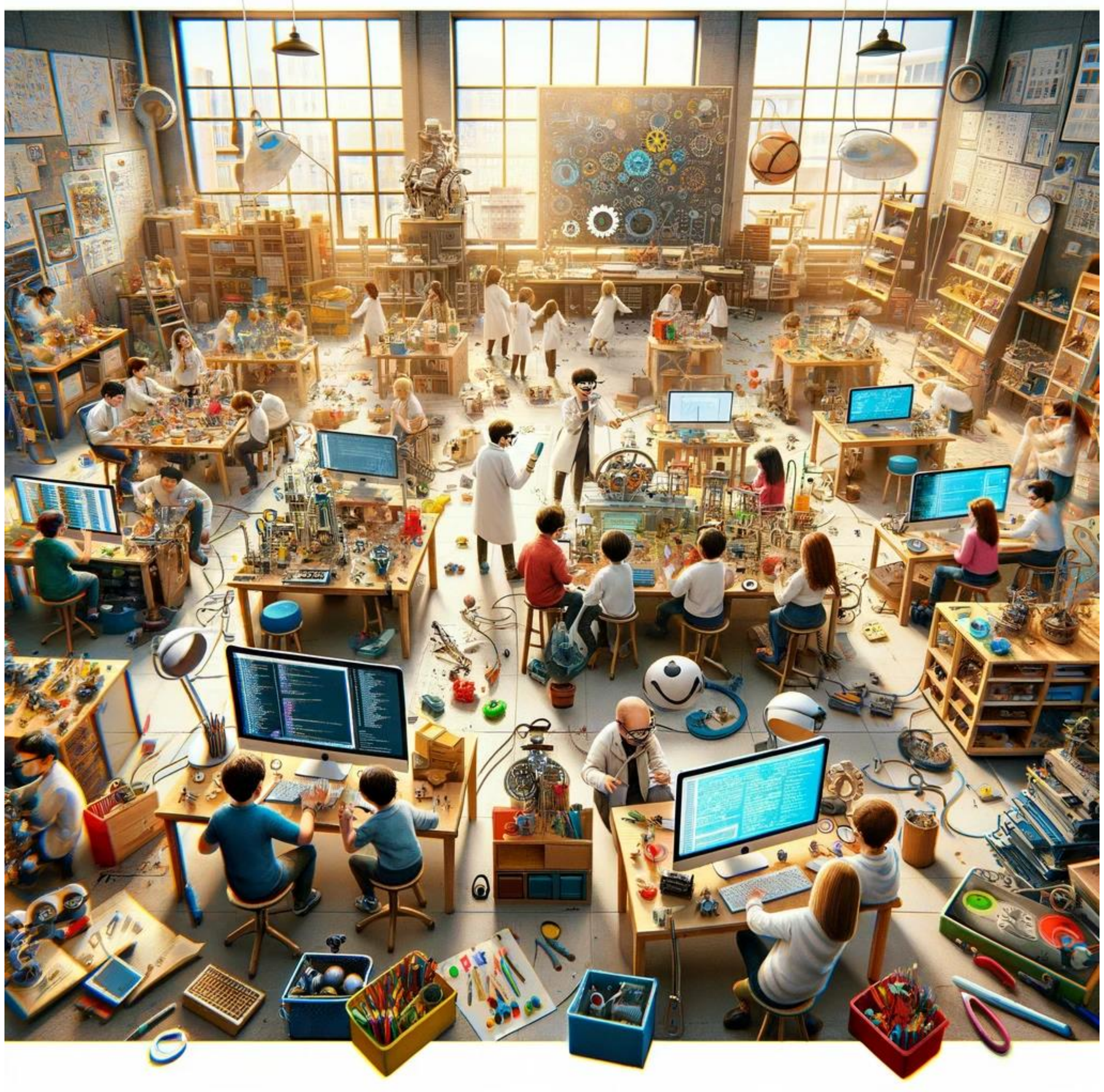
[About the project - Modeling at School (computationalthinking.guru)](https://computationalthinking.guru)

PH NÖ PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

Research Question

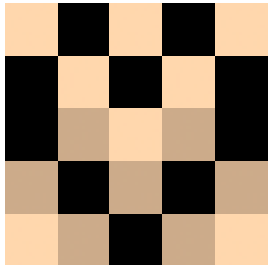
Key design principles for practical K-8 computational thinking (CT) learning environments (LEs) handbook, refined through design-based research (DBR) to enhance teacher confidence and efficacy in integrating CT into Basic Digital Education (BDE) for non-specialists in computer science (CS)?

8 Big Ideas of the Constructionist Learning Lab by Seymour Papert (Martinez, 2017)



1 - ‘Hello World’

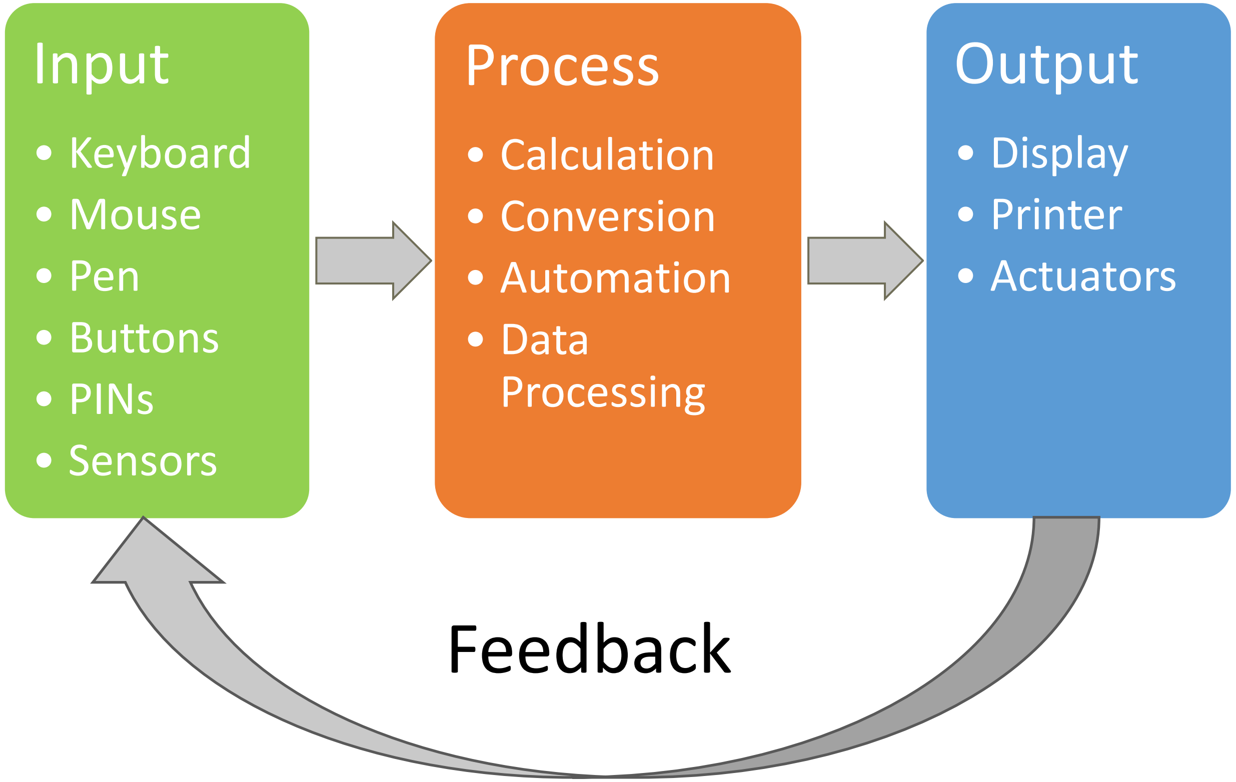
- First Programming Steps
- Get to know the micro:bit device
- Students make a heart appear

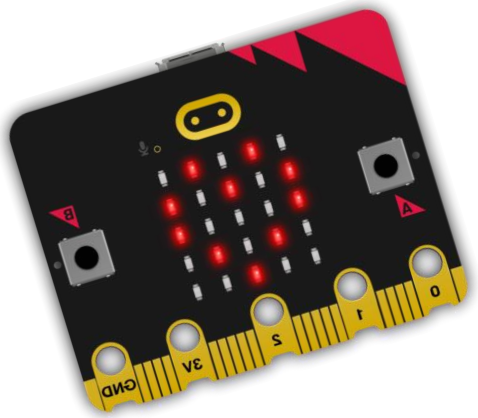


- Next
  draw own figures or letters

PÄDAGOGISCHE HOCHSCHULE
NIEDERÖSTERREICH

2 - Input-Process-Output





- Students set Button A to show something on display
- Image appears on 5x5 display
- Students set Button B to delete display

- Experiment with animations
- Automate “work” hide/show display

PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

3 - Evaluation & Debugging

- Utilize Makecode's step-by-step debugger
- Use slow motion "Snake"
- Verbalize program flow and actions
- Use storytelling techniques to explain code to peers

PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

4 - Pair Programming

- Turn possible budget constraints into advantage
- Two children working on same code and device
- Analogy of rally driving
  - One driver
  - One navigator
  - Frequently switch roles
- Clear communication
- Improves code quality

PH NÖ PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

5 - Open-Ended Learning & Makerspaces

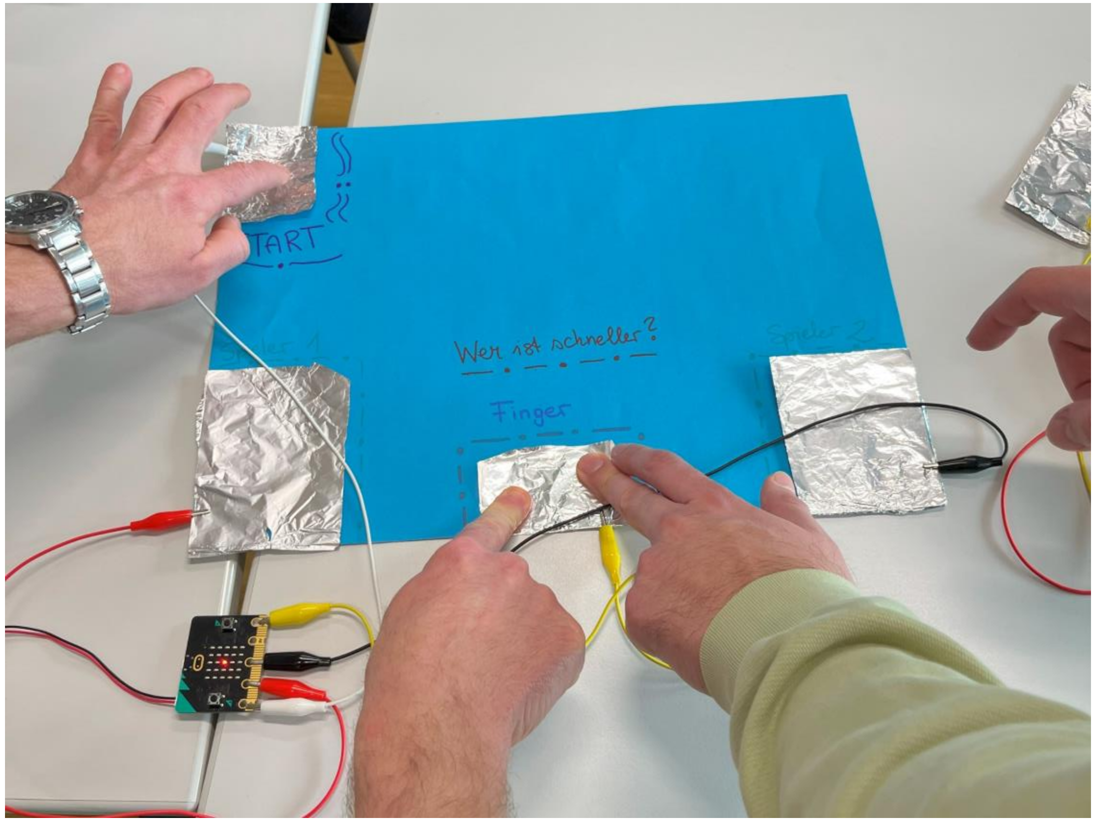
- Let Students make something that really matters to them

Example: Measuring soil for plant watering

- Textbook supports open-ended lessons in makerspaces
- Ideas for further projects, focus on making & tinkering
- Individual learning pace

PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

6 - Physical Computing & AHA! Experience



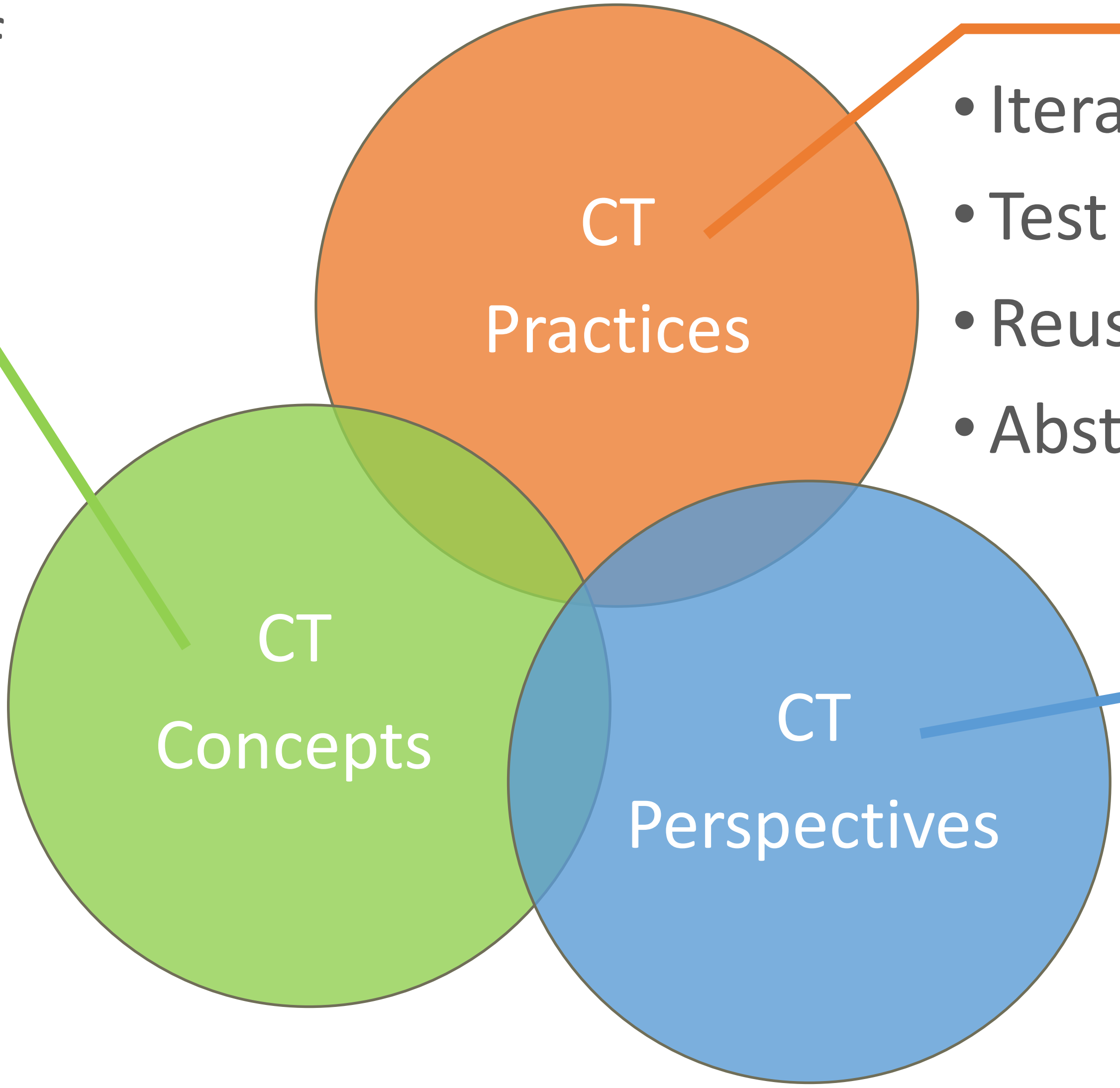
Reaction-Time Meter – textbook wiki example for physical computing

- Tutorials from textbook support first steps
- Step-Counter
  needs battery supply for portability
  → first AHA! Experience
- Programming concepts materialize
- Haptic aspect make CT concept more graspable
- Sensors and actuators can be attached, augment system
- Let more AHA! Moments occur

7 - 3D Framework

Full awareness of all 3 dimensions

- Sequences
- Loops
- Events
- Parallelism
- Conditionals
- Operators
- Data



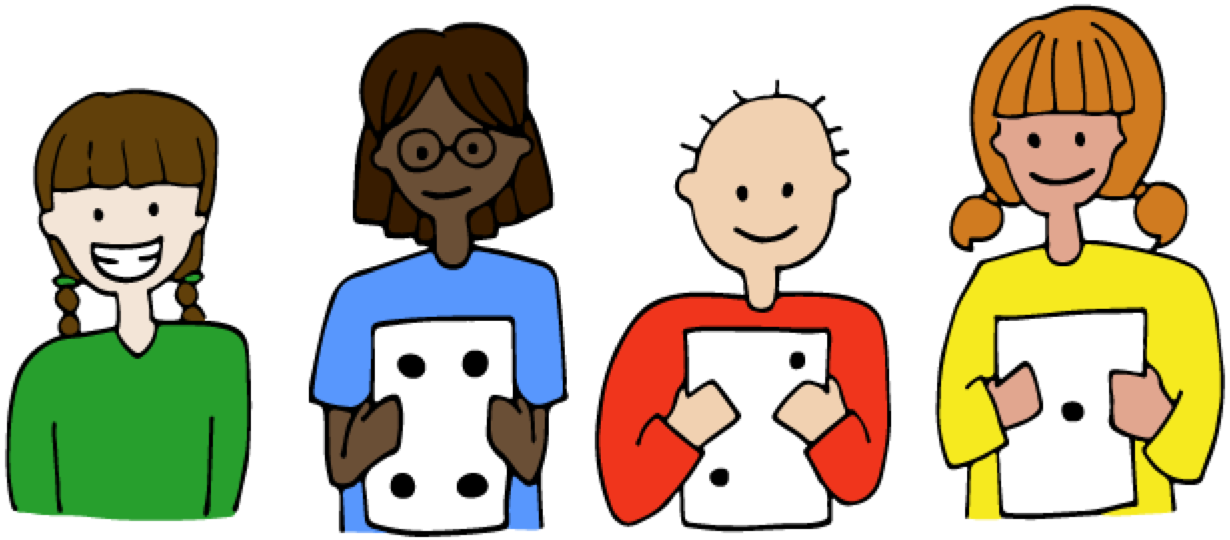
- Iterative & incremental
- Test & debug
- Reuse & remix
- Abstract & modularize

- Expressing
- Connecting
- Questioning

Brennan & Resnick (2012)

PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

8 - CS-unplugged Activities



Binary counting example – https://www.csunplugged.org/en/topics/binary-numbers/how-binary-digits-work-junior/

- CS fundamentals without use of computers
- Games and tasks
- Common items – cards, crayons, etc. – demystify CS concepts
- Free resources (CC BY-SA 4.0)

- Example

Parity magic trick

Behind the scenes demo of parity bit

PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

Discussion

- Frankfurt Triangle (Brinda et al., 2019)
  - Basis for Curriculum in Austria (BMBWF, 2022)
  - Combines CT, media and computer literacy
  - CT not explicitly mentioned
  - Challenge for teachers
- 8 Design Principles (DBR/EDR)
  - Effective learning and teaching strategies for gentle introduction to CS/CT
  - Best practice knowledge
  - Learning by doing, follow along guide
  - No prior CS/CT knowledge necessary

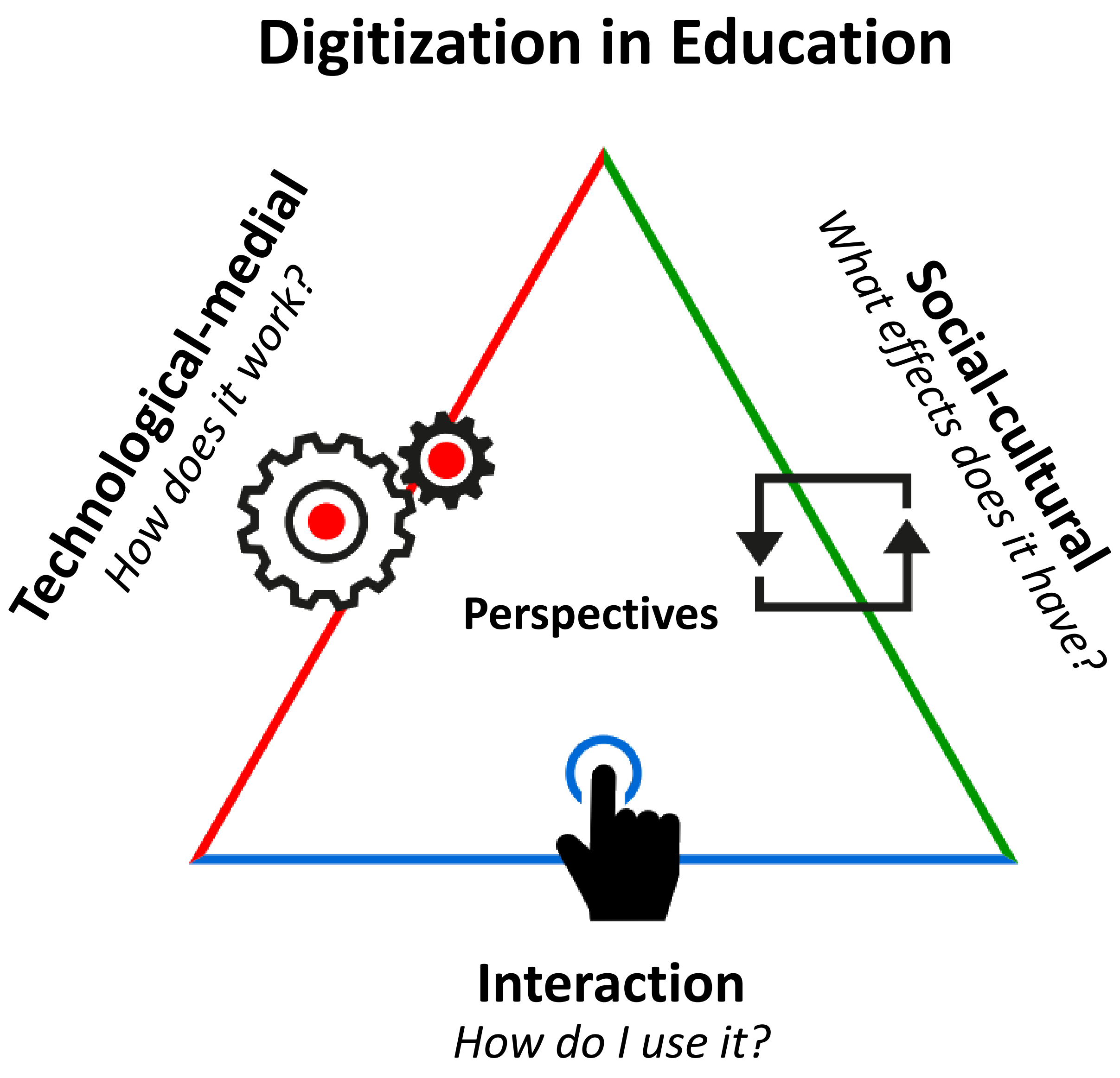


Figure: Adapted from Honegger & Salzmann (2018) CC-BY-SA (2018) with extensions by Kastner-Hauler (2024). https://mia.phsz.ch/Dagstuhl/GrafikUnterCCLizenz

PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

Conclusion

Practical Design Principles

- Foundation for CT classroom integration
- Further research planned for evaluation
  - BDE teacher training course
  - Impact on acceptance of CT
  - Incorporation into one's teaching
  - Adaption and creation of learning material
- Refine content and design
  - Iterative reflections
  - Solid support handbook
- Appendix demonstrates possible application of principles by a fictive teacher persona "Jane Doe"

Picture Credits & Contact

- p. 1 CSEDU 2024 https://insticc.org/images/wise/events/3693/banners/web.webp
- p. 4 Computational Thinking Adapted from Selby & Woollard (2013) with extensions by Kastner-Hauler (2021).
- p. 5 Blocks https://makecode.microbit.org
- p. 5, 11 micro:bit https://microbit.org/design-your-microbit/v2/
- p. 6, 15 micro:bit textbook wiki https://microbit.eeducation.at/wiki/
- p. 8 Higher-level frameworks – see page
- p. 17 CS-unplugged – see page
- p. 18 Frankfurt triangle – see page

- p. 3, 9, 10, 12, 13, 14, 19 KI generated images GPT-4/DALL-E with Openai and Microsoft Copilot
- p. 4, 7 Slide templates https://presentationgo.com

All other images

- Self-representations by Oliver Kastner-Hauler

PH NÖ

University of Education
Pädagogische Hochschule
karlsruhe

JKU
JOHANNES KEPLER
UNIVERSITÄT LINZ

oliver.kastner@ph-noe.ac.at