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A Learning Environment to Promote the Computational Thinker:

A Bebras Perspective Evaluation

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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 struggle
  - Feel “not well-prepared” for new subject
  - Few teaching material to scaffold and build confidence

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Learning Environment for CT & Problem-Solving

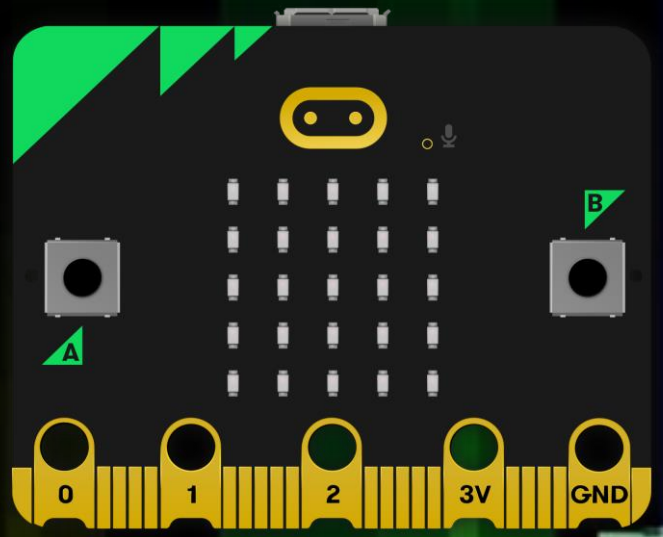
- Facilitate CT acquisition through
  - Physical computing → haptic approach
  - Block-based programming
  - Bebras tasks and problem-solving
- Learning Environment (LE) for CT education
  - Guide for teachers and students
  - No prior/formal CS/CT knowledge needed
- Evaluation
  - Bebras assessments pre-/post-tests, quasi-experimental design

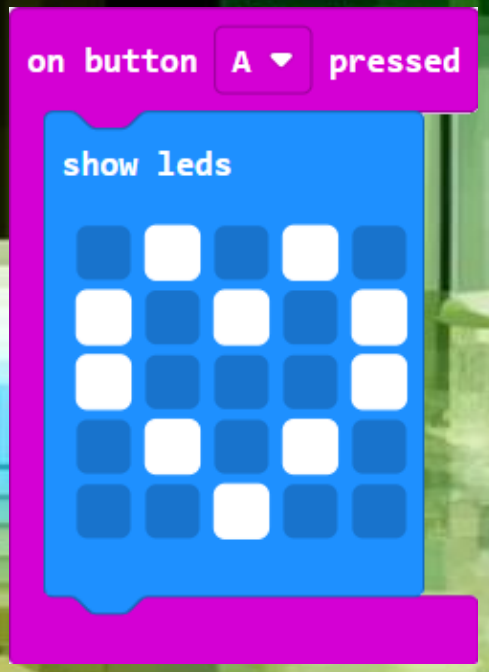
Background (1, 2)

- Physical Computing
  - Create tangible real-world products
  - Artifacts manifest mental concepts
  - Visualize thinking process
- Block-Based Programming

- Easy code construction for lower grades

- Snap-together blocks in playful way, like building a toy house





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Background (3)

- Bebras International Challenge
  - Higher-order thinking skills
  - CS/CT concepts without prior knowledge
- Bebras tasks include
  - Problem-solving
  - Knowledge construction
- Operational Implementation
  - Online Assessment Questionnaires with Lime-Survey

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Research Question*

Does the design of the physical computing learning environment with the micro:bit device scaffold and support the acquisition of both computational thinking and problem-solving skills?

**Multicycle EDR study to enhance CT & problem-solving*

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Research Design

- In-Service Training on LE
  - OER wiki & assessments
  - Supervised online community
- Pre-Test
- LE Intervention (5-8 weeks)
  - 2 age groups (Benjamins 5/6th grade, Cadets 7/8th grade)
  - Experimental and control group in both age groups
- Post-Test

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Participants

- Students n=240

  f=119, m=121; 10-14 years old; grades 5-8

  Benjamins 5/6th grade n=73

  Cadets 7/8th grade n=167
- Austria-wide project during pandemic circumstances
- Sub-sample selection

  Teachers from in-service training with direct contact (real-world and online-community) during implementation were selected
- Research guidelines & ethical standards

  Austrian Agency for Research Integrity (OEAWI)

  And all universities involved

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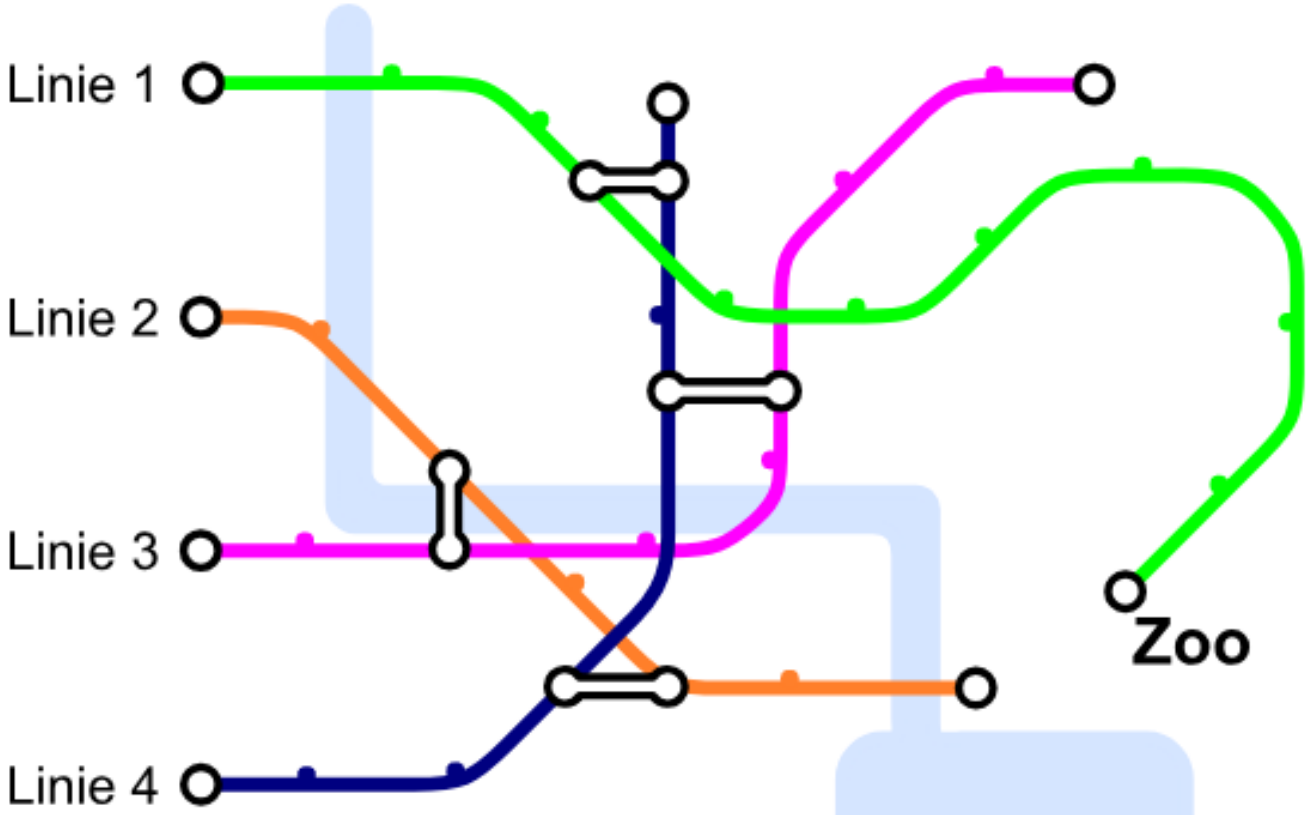
Bebras Tasks Assessments
*"Train lines to the zoo"**

- 10 Bebras problem-solving tasks questions

  5 pre- and 5 post-test, different assessment questions
- Task selection by expert panel of university teachers (CS) in 3 cycles
  - Pre-screening of 40 questions
  - 24 questions re-calibrated in difficulty
  - Final 10 questions selected
- Lime-Survey Implementation
  - Multiple Choice Questions
  - Max. 56 points per set (2 easy, 2 medium, 1 hard)
  - 14-point positive bias to avoid scores below zero



** Only 1 change? – grades 5/6, easy, 2018)*

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Learning Environment

- Playful CT experimentation
  - 4 units of inquiry-based learning (IBL) that implement 5E instructional model
  - OER textbook wiki (including task extensions)
- Unit 1
  -Hard- and software familiarization
  -Instructional material, usage of spoiler links
  -1 easy example task
- Unit 2
  - Advanced software coding
  - Tutorials and videos to complement textbook wiki
  - External circuitry (e.g. soil moisture)
  - 1 medium example task
- Units 3 & 4
  - Expand on previous, allowing flexible adjustment
  - 1 medium & 1 “any” difficulty example task

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Results: Pre-/Post-Test Assessments

- Maximum Score (56) 19x of n=240
  - 5x Benjamins 5/6th grade
  - 14x Cadets 7/8th grade (2x control group)
- Experimental Groups
  - Benjamins 5/6th grade improved from M=21.22 to M=25.00
  - Cadets 7/8th grade improved **strongly** from M=24.07 to M=32.24
- Paired samples t-test effect size
  - Cadets **significant** Cohen's d=.458
  - Benjamins non-significant Cohen's d=-.085

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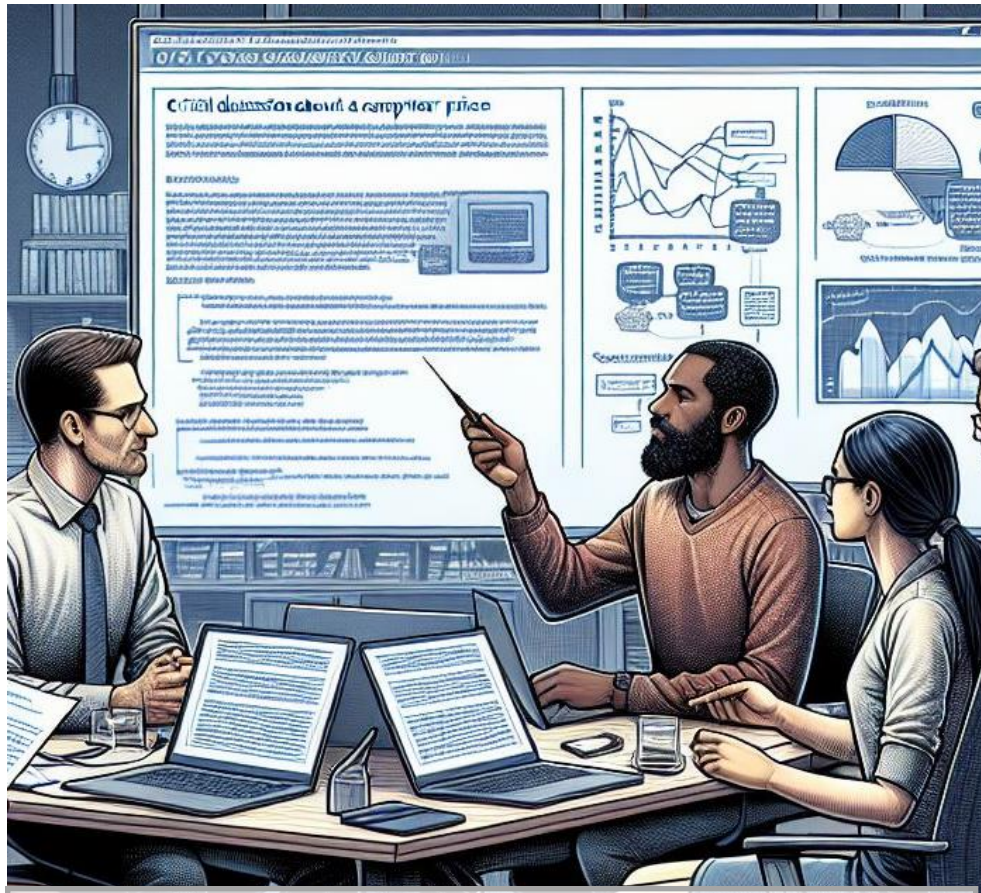
Discussion

- Benjamins sample with uneven age distribution
  from group 5/6th grade only **7**/73 in grade 6
- Assessment procedures not followed
  Teacher failed to provide deletion code*
  Outliers with high scores in very short time**
  Pre-set defaults included out-of-scope self-testers**
- Arbitrary interpretations of LE implementation
  Number of lessons, number of tasks**
- Stricter supervision, clear communication, highlighting mutual benefits
  Teacher's active part in collecting data*
  Key implementation details**
  Avoid teacher fear of assessments**



*for collection of teacher data
win-win situation of assessing own teaching
**contact in case of implementation doubts

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Conclusion & Outlook

Promotion of Computational Thinker
- Block-based coding & physical computing
- Bebras tasks assessment

- Instructional materials & best-practice guidelines
  - Translating CT for classroom teaching integration
  - Enhancing confidence and efficacy without prior CS/CT knowledge
- Combination of materials for LE
  - OER textbook & wiki (Inquiry-based learning)
- Significant impact on older students
  - Direction of development approved
- Further research needed/ suggested
  - Design principles (in publishing)
  - Teachers need tighter supervised guidance
  - Younger students grade 5/6 more/different support
  - “Bebras-unplugged” 2nd trial group

Picture Credits & Contact

- p. 1 ISSEP 2024
  About - 17th ISSEP 2024, Budapest, Hungary
  https://issep2024.elte.hu
- p. 4 BBC micro:bit
  https://microbit.org/design-your-microbit/v2/
- p. 4 Code Blocks
  https://makecode.microbit.org
- p. 9 Bebras Task OCG (2018)
  https://www.coding4you.at/biber/2018/biber_5_6/index.html
- p. 3, 4, 5, 6, 7, 8, 10, 11, 12, 13
  KI generated images
  GPT-4/DALL-E with OpenAI and Microsoft Copilot

All other images

- Self-representations by Oliver Kastner-Hauler

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