Professional Development Program

Computational Thinking in STEAM

Description of the activity:	Introduction to Computational Thinking and some ideas on how to connect it into STEAM (to develop further and expand)
Target group(s):	Primary education teachers
Keywords:	computational thinking, programming, STEAM
Duration of activity:	1,5 hours
Description of activity environment and materials needed:	Done in any classroom Computers needed if the examples are explored deeper

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NACIONALINĖ ŠVIETIMO AGENTŪRA

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COMPUTATIONAL THINKING IN STEAM

What is computational thinking and
how to take advantage of it in STEAM education?

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WHAT IS COMPUTATIONAL THINKING?

- Computational Thinking (CT) is something programmers need to be able to program.
- CT involves programming elements, strategies and thinking processes.
- Brennan and Resnick (2012) divided CT into three areas: Concepts, Practices and Perspectives.
    - … with additions from Zhang and Nouri (2019)

K. Brennan ja M. Resnick. 2012. New Frameworks for Studying And Assessing the Development of Computational Thinking.
http://scratched.gse.harvard.edu/ct/files/AERA2012.pdf
L. Zhang ja J. Nouri. 2019. A Systematic Review of Learning Computational Thinking Through Scratch in K-9.
https://doi.org/10.1016/j.compedu.2019.103607

CONCEPTS

Common programming concepts also translate outside programming – they are the “things”.

Sequences	“series of individual steps or instructions that can be executed by the computer”
Loops	“a mechanism for running the same sequence multiple times”
Events	“one thing causing another thing to happen”
Parallelism	“sequences of instructions happening at the same time”
Conditionals	“ability to make decisions based on certain conditions, which supports the expression of multiple outcomes”
Operators	“support for mathematical, logical, and string expressions, enabling the programmer to perform numeric and string manipulations”
Data	“storing, retrieving, and updating values”
Input and Output	specific inputs results consistently in specific outputs inside the programs (i.e. functions) and outside while using the program

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PRACTICES

Practices refer to the processes of construction – i.e. the action.

Being incremental and iterative	“Designing a project is an adaptive process, one in which the plan might change in response to approaching a solution in small steps.”
Testing and debugging	“It is critical for designers to develop strategies for dealing with – and anticipating – problems.”
Reusing and remixing	“Building on other people’s work has been a longstanding practice in programming.” “Reusing and remixing support the development of critical code-reading capacities and provoke important questions about ownership and authorship.”
Abstracting and modularizing	“Building something large by putting together collections of smaller parts is an important practice for all design and problem solving.”
Predictive thinking	Outputs are predicted while programming and compared to the actual outputs of the program to see if the program works the way it should.
Reading, interpreting and communicating code	To be able to read und understand the code is necessary in programming (especially in debugging) and communicating it to others in computational terms is needed when working with others.
Multimodal design	Using different medias (such as sound and movies) in programs.

PERSPECTIVES

Perspectives describe shifts in perspectives while programming.

Expressing	“Computational thinker sees computation as something they can use for design and self-expression.”
Connecting	“Creativity and learning are deeply social practices: there is value of creating with others and value of creating for others in designing computational media.”
Questioning	“Computational thinker feels empowered to ask questions about and with technology: they don’t feel disconnected from the complex technologies of everyday life.”
User interaction	When the interaction between the user and the computer or program is taken into account while designing and programming, the programs will be more intuitive, user friendly and accessible.

CONNECTING CT TO STEAM

CT is tightly related to programming via the elements of programs and the act of programming, and programming can be used in relation to any subject!

- programming your own calculator with complicated functions (Mathematics)
- programming drawings and animations (Art)
- and so on!

CT is also related to thinking about, using and developing technology which, in todays society, we can find every where.

- thinking about how devices and apps are made
- using different devices and other pieces of technology (for example as part of science project)
- developing new devices and apps – and new ways to use them!

Other ideas on how CT connects to STEAM?

Discuss!

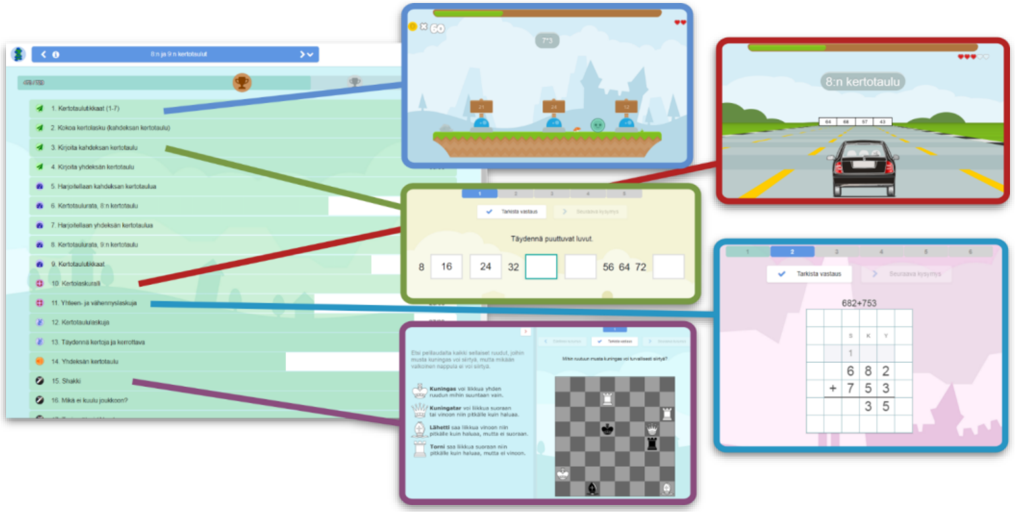
CT IN STEAM IN PRACTICE – TWO EXAMPLES

Math & CT Learning Paths in ViLLE

ScratchMaths project

WHAT IS VILLE?

- #1 Digital Learning Environment in Finland
- 20+ Years of Finnish educational excellence with gamification and AI, various subjects & topics
- Up to 3 hours more active learning per week
- SaaS: Software as a Service (web-platform)


8:n ja 9:n kertotaulut

1. Kertotaulutikkaat (1-7)
2. Kokoa kertolasku (kahdeksan kertotaulu)
3. Kirjoita kahdeksan kertotaulu
4. Kirjoita yhdeksän kertotaulu
5. Harjoitellaan kahdeksan kertotaulua
6. Kertotaulurata, 8:n kertotaulu
7. Harjoitellaan yhdeksän kertotaulua
8. Kertotaulurata, 9:n kertotaulu
9. Kertotaulutikkaat
10. Kertolaskuralli
11. Yhteen- ja vähennyslaskuja
12. Kertotaululaskuja
13. Täydennä kertoja ja kerrottava
14. Yhdeksän kertotaulu
15. Shakki
16. Mikä ei kuulu joukkoon?

Täydennä puuttuvat luvut.

8 16 24 32 56 64 72

682+753

Etsi pelilaudalta kaikki sellaiset ruudut, joihin musta kuningas voi siirtyä, mutta mikään valkoinen nappula ei voi siirtyä.

Kuningas voi liikkua yhden ruudun mihin suuntaan vain.

Kuningatar voi liikkua suoraan tai vinoon niin pitkälle kuin haluaa.

Lähetti saa liikkua vinoon niin pitkälle kuin haluaa, mutta ei suoraan.

Torni saa liikkua suoraan niin pitkälle kuin haluaa, mutta ei vinoon.

Mihin ruutuun musta kuningas voi turvallisesti siirtyä?

Turku Research Institute for Learning Analytics trila.fi

Laakso, MJ., Kaila, E. & Rajala, T. **ViLLE – collaborative education tool: Designing and utilizing an exercise-based learning environment.** Educ Inf Technol 23, 1655–1676 (2018). https://doi.org/10.1007/s10639-017-9659-1

DIGITAL AND GAMIFIED LEARNING PATH IN MATHEMATICS & COMPUTATIONAL THINKING

Grades: 1 – 12, **aligned with any curricula**

Weekly lessons: **457** (40+ per grade level)

Exercises: **17 973** (25 - 35 per lesson)

Co-designed and co-created with the teachers:
- Weekly ready-made-lessons for teachers
- **Computational thinking tasks included!**
- Personalization and differentiation made easy
- **Integrates to teachers existing workflows!**

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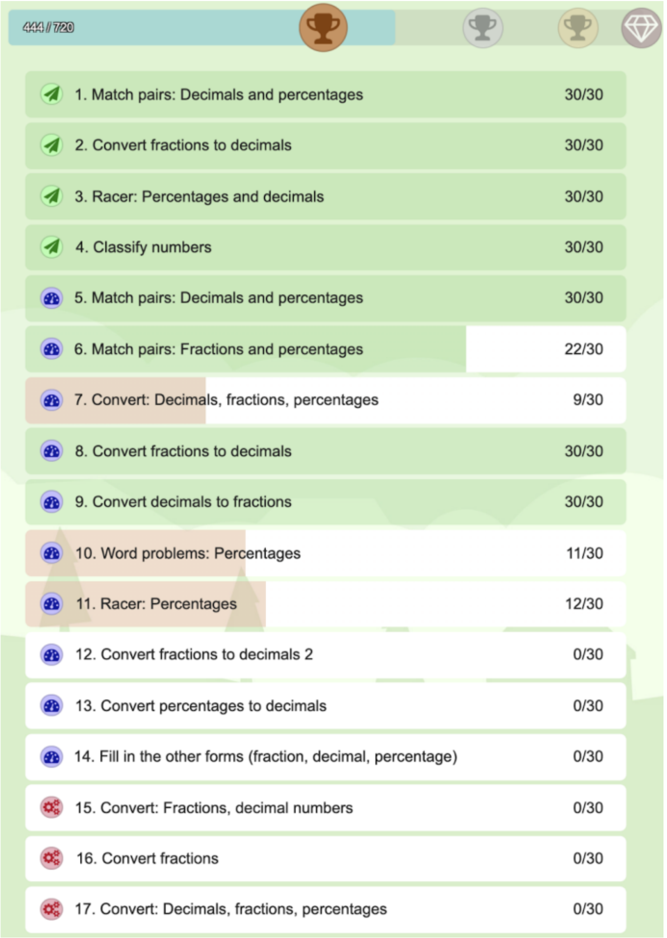
BASIC CONCEPT

- 1 lesson per week + homework
  - 25-35 exercises, 350-500 tasks
  - 45-90 minutes to complete a lesson
  - Computational thinking & logical exercises
- Active learning & gamification & continuous assessment
- Easy personalization & differentiation for learners
- Integrates into teacher existing work!
- Also used in Bebras Challenge that promotes Informatics and Computational Thinking!

Easy

Moderate

Hard



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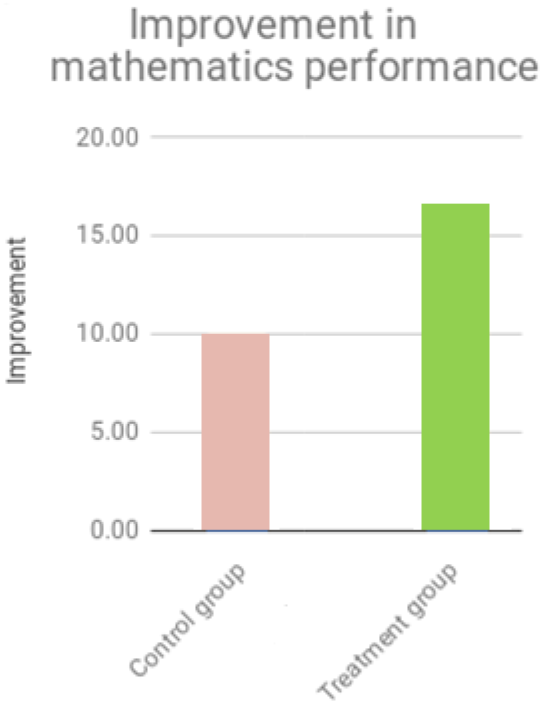
1. Match pairs: Decimals and percentages	30/30
2. Convert fractions to decimals	30/30
3. Racer: Percentages and decimals	30/30
4. Classify numbers	30/30
5. Match pairs: Decimals and percentages	30/30
6. Match pairs: Fractions and percentages	22/30
7. Convert: Decimals, fractions, percentages	9/30
8. Convert fractions to decimals	30/30
9. Convert decimals to fractions	30/30
10. Word problems: Percentages	11/30
11. Racer: Percentages	12/30
12. Convert fractions to decimals 2	0/30
13. Convert percentages to decimals	0/30
14. Fill in the other forms (fraction, decimal, percentage)	0/30
15. Convert: Fractions, decimal numbers	0/30
16. Convert fractions	0/30
17. Convert: Decimals, fractions, percentages	0/30

Pluhár, Z. et al. (2022). **Bebras Challenge in a Learning Analytics Enriched Environment: Hungarian and Indian Cases.** In: Bollin, A., Futschek, G. (eds) Informatics in Schools. A Step Beyond Digital Education. ISSEP 2022. Lecture Notes in Computer Science, vol 13488. Springer, Cham. https://doi.org/10.1007/978-3-031-15851-3_4

RESEARCH BASED: IMPACT ON STUDENTS RESULTS

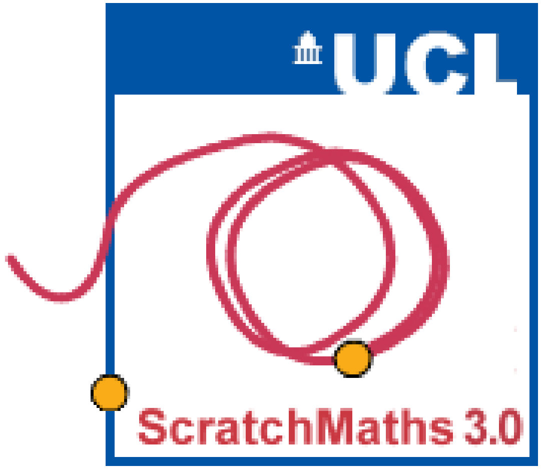
- In 15 weeks study (3rd grade):
  - student performance improved 12% (39% more than in control group) and
  - arithmetic fluency improved 11 % (45% more than in control group).
- Children chose to work more than 50% extra at home and during weekends (3rd grade). 71% less mistakes overall (2nd grade).
- Marks increased by one whole mark on average. The improvement was permanent as observed over 2 years (grades 5-6, 15-20%).



15 week study, 3rd gr, Mar 2018

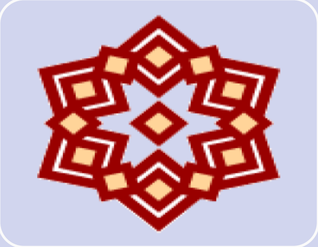
SCRATCHMATHS

- ScratchMaths is a two-year computing and mathematics-based curriculum for grades 5 and 6.
- Its aim is to enable pupils to engage with and explore important mathematical ideas through learning to program.
- It uses Scratch – a free online programming environment.



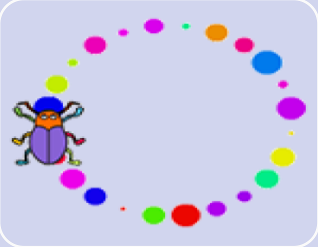
https://www.ucl.ac.uk/ioe/research/projects/ucl-scratchmaths/ucl-scratchmaths-curriculum

SCRATCHMATHS MODULES



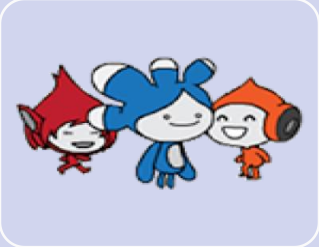
1: Tiling patterns

- Theme: repeating patterns
- CT: sequence, loops, algorithms, debugging
- Math: symmetry, angles, negative numbers



2: Beetle geometry

- Theme: creating drawings
- CT: sequence, loops, randomness, expressions, initialisation
- Math: geometry

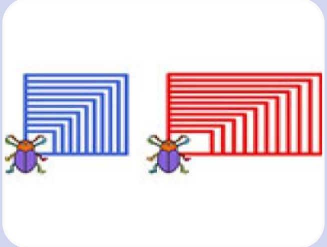


3: Interactive sprites

- Theme: interactive behaviours between multiple sprites
- CT: parallelism
- Math: coordinates, multiplication, factors

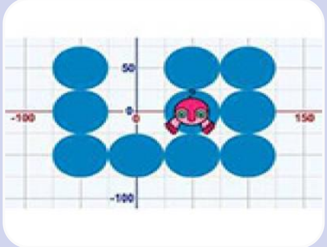
4: Building with numbers

- Theme: exploring place value
- CT: broadcasting
- Math: place values



5: Exploring mathematical relationships

- Theme: exploring poportionality and ratio
- CT: variable
- Math: poportionality, ratio



6: Coordinates and geometry

- Theme: exploring coordinates
- CT: variable
- Math: coordinates, scale

GET FAMILIAR WITH SCRATCHMATHS

- Choose a module and get to know it!
  - If programming or Scratch is not familiar, choose one from the beginning. Otherwise choose something that interest you.
- Would you use the module? Would you include everything in the module? Would your students like the module?
- Discuss with partner!
- https://www.ucl.ac.uk/ioe/research/projects/ucl-scratchmaths/ucl-scratchmaths-curriculum

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