

# COGNITIVE GAMES FOR COMPUTATIONAL THINKING

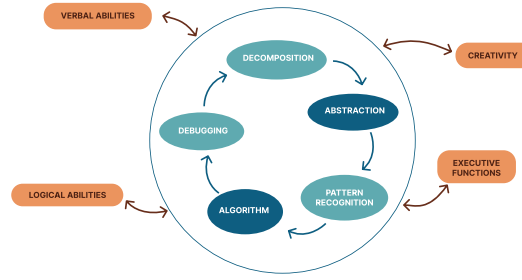
## Designing Cognitive Mini-Games for CT and Executive Functions Training

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### ABSTRACT

Computational Thinking (CT) is often taught through coding activities, which tend to overlook the cognitive processes underlying problem solving. This work introduces ATHeNA, a game-based approach that integrates CT concepts with executive functions training through a set of structured mini-games embedded in a narrative environment. Through a mechanism-driven design and participatory development, the project aims to provide a cognitively informed, scalable alternative to traditional CT tools, supporting both learning and cognitive development.



### WHY COMPUTATIONAL THINKING?

Computational Thinking (CT) is a key 21st-century skill, but current educational tools often focus on technical aspects (e.g., coding) while neglecting the underlying cognitive processes. What is missing is the cognitive side of problem solving.

Children don't just learn what to do, they struggle with: planning, remembering, adapting strategies. These processes are known as Executive Functions (EFs).

### THE ATHeNA PROJECT



We introduce ATHeNA (Algorithmic Thinking, cognitive Enhancement and Active learning):

A game-based learning environment that:

- integrates **CT concepts + Executive Functions**
- uses **mini-games** instead of coding tasks
- embeds learning in a **narrative** space environment

→ Not "learn to code"  
→ But "learn how to think computationally"

### BEHIND THE SCENES: METHODS

- **LITERATURE REVIEW**  
It started with delving literature on current knowledge of CT, effective approaches and its relationship with cognitive abilities, but also gaps.
- **EMPIRICAL STUDIES CONDUCTED BY OUR LAB**  
Studies were conducted to assess effective approaches for CT training, relationship between CT and different cognitive abilities such as verbal skills and creative thinking as well.
- **FROM DATA TO DESIGN**  
We didn't design this alone but with: **children, teachers and experts.**  
Through **participatory design workshops**, we collected: drawings, stories and prototypes shaping both the **mechanics** and the **narrative**
- **DEVELOPMENT AND VALIDATION**  
The game suite is going to be developed in a plugged and unplugged version which will be tested in an ecological setting.

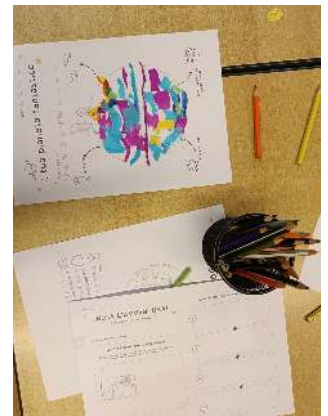


Figure 1. ATHeNA design workshop with children.

## INTO THE GAME

ATHeNA is a set of short **mini-games** inside a narrative world (a "Computational Galaxy" with small characters called Bitlings).

Each mini-game targets specific components according to a **simple rule**:

**A concept (CT) + a constraint (EF) = a mechanic (gameplay)**

A child is not just asked to solve a problem → but to solve it under cognitive **constraints** (e.g., limited memory, changing rules, time pressure)

→ The key is not the task itself, but how the player must be cognitively engaged during it, requiring them also to adopt **computational strategies**.



Figure 2. ATHeNA mini games overview.

Mini-Game	CT Concept	Executive Functions	Core Mechanic
Mission Warm-Up	Attention activation	Working memory	Detect repeated signals (n-back)
Break It Down	Decomposition	Planning, attention	Identify components of a complex shape
Glitchers Attack	Pattern recognition, debugging	Flexibility, inhibition	Rule switching with feedback
Plan It Path	Algorithms	Working memory, planning	Pre-plan full sequence (no correction)
Rocket Run	Debugging, conditionals	Monitoring, flexibility	Fix system errors under changing conditions
Loop Escape	Patterns, loops	Flexibility, attention	Detect and adapt to looping patterns

Figure 3. Mini-games rationale.

### A WORK IN PROGRESS

ATHeNA proposes a shift in how Computational Thinking is taught: not only as a set of technical skills, but as a cognitive process fostering and fostered by executive functions, by embedding CT concepts into structured mini-games.

At the same time, the design highlights key tensions:

- balancing cognitive challenge and game engagement
- ensuring conceptual clarity and transfer beyond gameplay

### REFERENCES

Find the bibliography and the paper here



### WANNA JOIN?

Interested in building the game? We're currently moving to the technical development (game mechanics, implementation, and system design) Let's talk!

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