Project Title:

DRL:1640135 Integrating Computational Thinking into Mathematics Instruction in Rural and Urban Preschools

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Overview

Public media producers from WGBH and Kentucky Educational Television and researchers from Education Development Center teamed up on the project Integrating Computational Thinking into Mathematics Instruction in Rural and Urban Preschools (DRL 1640135). Modeled on Clements's (2007) Curriculum Research Framework, the project team developed a **learning blueprint** and an **alignment document** stating relationships between the learning goals and preschool math instruction. The team then **iteratively developed and tested prototypes of 3 digital tablet apps and 12 hands-on activities** that focused on the **CT concepts** of **sequencing, debugging, and modularity** in ways that leverage children's math skills. After classroom observations with 16 teachers in rural and urban preschools, researchers analyzed observation notes and identified promising practices and areas for improvement for the prototypes. Videos from the classroom visits were analyzed for children's CT learning and teachers' CT understanding related to the CT skills of debugging, modularity, and sequencing.

Project Findings

Integration of Math:

- Children appeared to be **very comfortable** with the math knowledge required across the set of digital apps and hands-on activities. Teachers also appeared very confident in their strategies to support the math components of the activities.
- Teachers were **more confident** in their math abilities than CT. Thus when they modified activities, these modifications led to focus children more on the math skills they could perform versus how using math supported applying CT skills to solving a problem.

CT Learning Opportunities & Challenges

- Some of the sequencing and modularity activities had goals that were **motivated by efficiency** (i.e., doing something fast like packing a picnic lunch or getting a character to a goal location in the shortest number of steps). However, it appears that children did not seem to achieve the same level of success when the activities attempted to motivate kids to be efficient.
- Activities that asked children to supply directions in the **smallest units possible** (like giving a robot instructions on how to brush its teeth) also appeared to be difficult for young children.
- It was observed several times that teachers would try to **limit the hands-on manipulation of materials** before children were given an objective or explicit instructions, seemingly to avoid too much time off-task with the activity's objective.

Select CT Core Idea Takeaways

- Children had an easier time **putting steps in order** as opposed to figuring out **what the steps were. (Algorithmic Thinking)**
- It was challenging for educators to encourage children to **isolate a sequencing error** rather than starting over when something is wrong. **(Algorithmic Thinking)**
- Children did not seem to naturally engage in a **systematic debugging process**, which is why when children encountered a problem, teachers played an important role in scaffolding the debugging process. **(Debugging)**
- Children seemed **more adept at the second step** of the debugging process – brainstorming ways to fix the problem – rather than noticing something at start of the debugging process. We interpret this as parallel to the findings for sequencing activities, in which children had an easier time putting steps in order as opposed to figuring out what the steps were. **(Debugging)**
- It was common for teachers to **let children start over** instead of guiding them through a debugging process to find an error that could be corrected.
- Observational data in classrooms showed that the **problem decomposition** aspect of the modularity activities was largely **teacher-directed** in most classrooms. Teachers often decided how to break down the job and assigned roles to children without them participating in the planning process. **(Modularity/Problem Decomposition)**
- Teachers would often simplify the activity so that children completed a specific objective (e.g., packing five picnic lunches) rather than solving the entire complex problem (e.g., wanting to take five friends on a picnic lunch and needing to bring enough food for everyone). By **reducing the problem to an objective**, it often removed the point that there are different ways and strategies that can be used to break a problem down into parts, particularly when teachers identified and focused children on a single way to tackle the problem. **(Modularity/Problem Decomposition)**

Exploration

CT/Mathematics Learning Process

Our model posits the following: As a baseline, a child brings his or her own intuition and experience to a problem-solving process, which influences each step of the process. At the start of the process, the child first notices something and identifies a problem or task based on what was noticed. The child then applies CT to this problem or task within the context of mathematics. This is a cyclic and systematic process that continues until the problem is solved or the task is accomplished. When the problem is solved or task accomplished, the outcomes are better-developed knowledge structures of both the content (e.g., CT content, such as sequencing, design process, and debugging, as well as mathematics content, such as numbers and operations, geometry, and patterns) and the learning process (in this case, mathematizing, which contributes to the development of computational literacy and mathematical thinking). These knowledge structures (computational literacy and mathematical thinking) then become part of the child's prior experience and intuition, which feed back into the same process the next time the child notices something and identifies a problem or task.