

Milestones in Computational Thinking and Mathematics Competencies in K-2

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Introduction

There is a push to integrate Computational Thinking (CT) and Computer Science (CS), usually in the form of coding, into K-12 education. At CiK, our goal is to inform the further development of effective CS standards and integrated mathematics instruction beginning in early childhood and working our way up. We are unpacking how children learn computational thinking, specifically, pinpointing developmental milestones for children's computational thinking and mathematical skills associated with coding.

- Computational Thinking (CT):** Problem solving effectively and efficiently with solutions that are reusable in different contexts (Shute, Sun, & Asbell-Clarke, 2017).

Research Question: How do CT and mathematical skills and strategies differ across Kindergarten, 1st and 2nd grades in elementary school settings?

Table 1- Item 7: Scores and Movement

Item 7	Correct	Incremental Movements	Movement-Arrow Correspondence	Flexible Arrow Meanings
K	20%	50%	40%	30%
1 st	40%	80%	80%	0%
2 nd	80%	90%	90%	0%

Table 1 shows the overall accuracy score of each grade level on Item 7, as well as how students used movements as they executed the task.

Methods

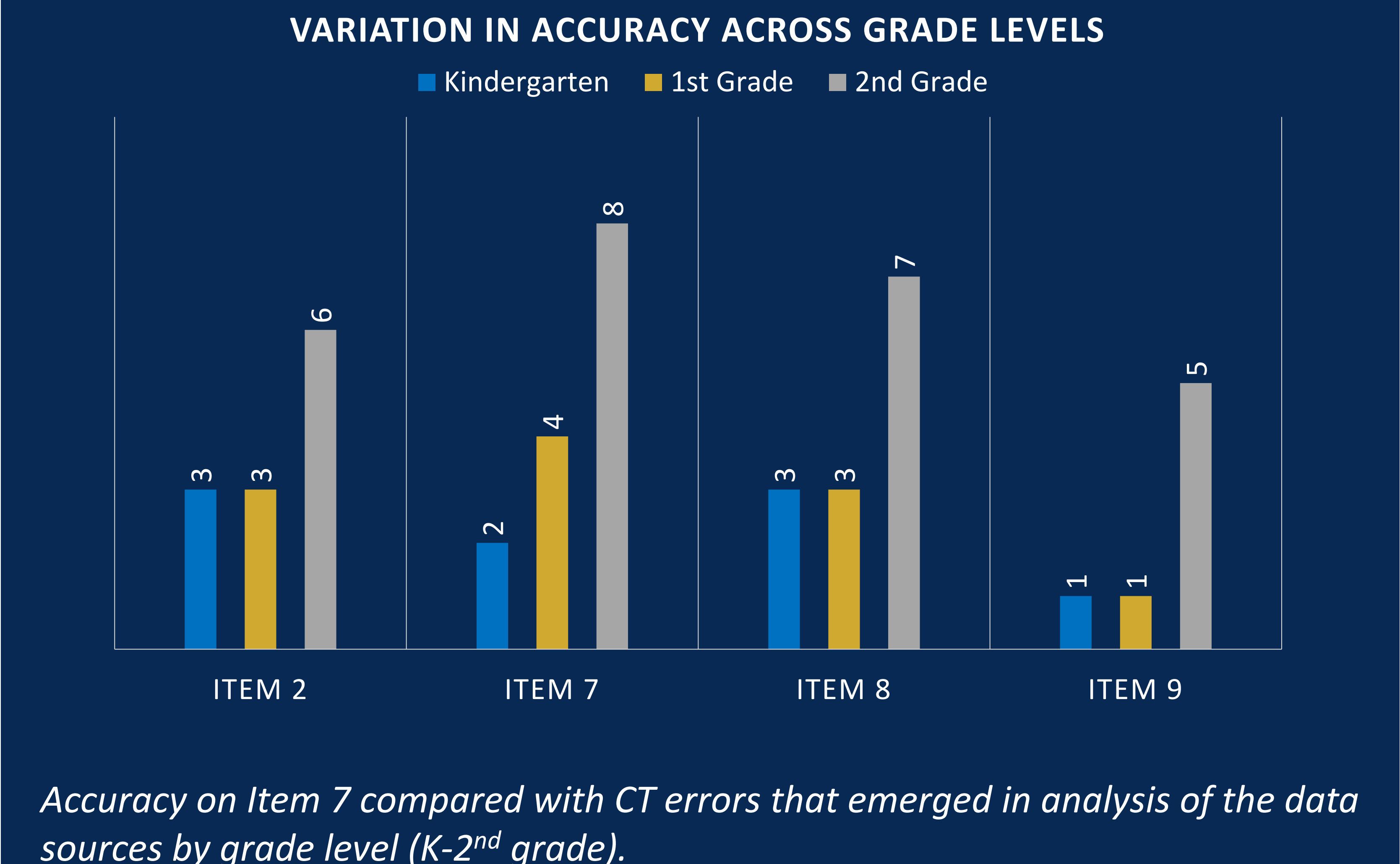
As part of a larger design-based research project, we developed performance-based assessment tasks that measure CT. This study examined a subset of 30 students answering four questions each to examine strategies that served and inhibited students as they solved the tasks.

- Participants:** 10 kinder, 10 1st grade, 10 2nd grade
- Setting:** one-on-one interviews across grade levels in 1 school
- Data source & analysis:** 4 CT/math assessment items that were iteratively coded over 3 rounds of open coding.

Figure 1 – Items and Variable Features

Images of the items, associated programs, and variable features analyzed.

Figure 2 – K-2 Variation in Accuracy



Results

For all four items analyzed, 2nd grade students consistently outperformed all younger age groups, but 1st graders and kindergarteners performed at similar levels. Common error themes emerged for each item regardless of age level. Item 2: Using the F arrow to move the agent "up" instead of forward. Item 7: Erroring due to location bias or using the arrows cardinally. Item 8: Using the right rotation arrow to travel to the right. Item 9: Reorienting the robot to their perspective then enacting.

Conclusion

Milestones for students in early childhood can hone current CS standards to meet students' needs through math integration points.

- Grouping K-2 could be detrimental to 2nd graders.
- Differentiated coding instruction using ScratchJr, Code.org, and coding toys such as Sphero can fill age-based gaps or extend coding.
- K: Focus on perspective taking, open-ended tasks, connection of three dimensions.
- 1st: Focus on rotation on a point.
- 2nd: Extend into number lines, coordinate planes, complex tasks.

