Computational Thinking Exhibited by Sixth Graders in Coding Board Games

Presentation by Melissa Rasmussen
Research performed with the Tabletop to Screens research group
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Background

- Computational Thinking (CT): patterns of thinking required to program computers

- Subjects: Sixth Graders, 24 total
Coding for Computational Thinking

Using data from 9 pairs of students:
3 pairs on each of 3 games
### Computational Thinking (CT) Coding Scheme

<table>
<thead>
<tr>
<th>CT Concept</th>
<th>Coding Criteria</th>
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<tbody>
<tr>
<td>Constraint</td>
<td>Reference to a rule of the game</td>
</tr>
<tr>
<td>Simulation</td>
<td>Physical attempt at a solution; may involve moving a game piece or a finger</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Determination of whether a given solution works or not</td>
</tr>
<tr>
<td>Decomposition</td>
<td>Breaking down of the puzzle into smaller, more manageable pieces</td>
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<tr>
<td>Debugging</td>
<td>Amendment of a proposed solution after recognizing a problem; counts even if it doesn’t fix the problem</td>
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<tr>
<td>Conditionals</td>
<td>An if-then statement basing an action on the current state of the program</td>
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<tr>
<td>Algorithms</td>
<td>Statement of a generalizable rule for problem-solving; must author an algorithm, not just execute one</td>
</tr>
<tr>
<td>Abstraction</td>
<td>Reference to a complex process with another name; must show that they equate the two</td>
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</table>
### Computational Thinking (CT) Examples

<table>
<thead>
<tr>
<th>CT Concept</th>
<th>Illustrative Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constraint</td>
<td>“It can’t touch purple.” A player correctly identifies a stipulation of the level. (Green Game)</td>
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<tr>
<td>Simulation</td>
<td>“Red, green, blue, red, blue, green.” Said while moving robot down the colored paths in that order. (Red Game)</td>
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<tr>
<td>Evaluation</td>
<td>“Yeah!” Immediately after above Simulation example, when the robot arrived at the end goal. (Red Game)</td>
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<tr>
<td>Decomposition</td>
<td>“1, 2, 3, to… nine, right?” Later: “So we already got this first part. From nine we have to go to red.” They break down the problem into two sections, where “nine” is the checkpoint between sections. (Red Game)</td>
</tr>
<tr>
<td>Debugging</td>
<td>“Oh. We were missing it. Cuz then we need to do this. Turn right for the blue command and then turn left for the red command…” Players identified and corrected a mistake in code execution. (Blue Game)</td>
</tr>
<tr>
<td>Conditionals</td>
<td>“If this purple is false, then this orange is true.” Whether they placed a token on orange depended on the state of the purple. (Green Game)</td>
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<tr>
<td>Algorithms</td>
<td>“So to jump over a space, we need two of these on here…” Problem-solving algorithm: when white space, place two move forwards. (Blue Game)</td>
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<tr>
<td>Abstraction</td>
<td>“Because it starts on blue, you only follow what’s on the blue. So it says to move forward two, it goes forward two.” “What’s on blue” is an abstraction for “move forward two”, the instructions on blue. (Blue Game)</td>
</tr>
</tbody>
</table>
% of Levels in Which a Pair Demonstrates Computational Thinking, by Game

Overall Occurrences

Blue Game

Red Game

Green Game
One Pair’s Gameplay of Red Game
Interviews
Using data from 18 students:
10 on blue game, 4 on red, 4 on green
Game Differences in Learning

Blue Game
- Teamwork
- Unplugged Programming
- Pattern Recognition
- Events
- Difficulty of Coding
- No answer

Red Game
- Teamwork
- Overcoming Obstacles
- Creative Problem Solving

Green Game
- Teamwork
- True/False
Opinions of Programming as a Career, by Gender

Girls (9)

“I could do it on my spare time... I don't want it as my job.”

“I like it. It's fun... Yeah, I don't think I choose it for like my career...”

“It's good. It's not my favorite, but a job but like...”

“...real coding with like, letters and the kind that my mom has to do for her college degree I would not enjoy. But the kind with the blocks I would enjoy.”

“I like [Scratch] because you can make your own games... I wouldn't want to do it for the rest of my life.”

“I find it fun but it's just it's not something I would want to do my whole life.”

Boys (9)

“It can give you a career. Like it can help you with a career that you choose.”

“I think it's something that you can really use to either have fun or use it in your actual life to get like a job or something.”

When two boys were asked whether this could be a job for them:

“Next year, middle school, depending on what I like, I'm going to do coding class in middle school. To see [if] I like it.”

“I've been wanting to do like computer engineering, whether that's like building computer parts or like coding computer things..”
• We developed a coding scheme for computational thinking that could be applied to other board game studies.
• As expected, different board games showed different types of computational thinking.
• The longer students spent on a particular level, the more computational thinking they exhibited.
• Students perceived the different board games as teaching different skills.
• The boys and girls we interviewed expressed drastically different views of programming as their potential future career.