BCTt
Beginners Computational Thinking Test
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UNED
Computational Thinking (CT)

**Many definitions**

- Human problem-solving process that requires abstract thinking

**BROAD DEBATE**

**Many breakdowns**

- Abstraction
- Decomposition
- Generalization
- Iteration
- Debugging
- Algorithms

Thinking skills that precede programming, and are applied in understanding a problem and formulating a solution like a computer scientist.

Computational Thinking (CT)

CONSENSUS

Fundamental skill required to adapt to the future

Should be taught at schools

Programming exposes students to CT
Computational Thinking (CT)

- Many frameworks

3D Framework (Brennan & Resnick*)

- CT Concepts
- CT Practices
- CT Perspectives

Questions

When to teach?

How to assess?

How to teach?

What to teach?
Questions

When to teach?

How to teach?

What to teach?

How to assess?
Assessment

When to teach?
How to teach?
How to assess?
What to teach?

Types of assessment

Traditional test
Portfolio
Survey
Interview

Focused on middle school grades and specific programming environments
Computational Thinking Test (CTt) *

Aimed at 10 to 16 years old

3D Framework

Stand-alone assessment instrument

Reliability and criterion validity, psychometric approach

Aligned with the international standards

CT concepts

CT practices

CT perspectives

Beginners Computational Thinking Test (BCTt)

- Based on CTt
- Stand-alone assessment instrument
- 5 to 10 years old
- Form / content adaptation
- Substantial improvements
BCTt v.1 Design

- **25 items long**
- **40 minutes**
- **3 alternative responses**
- **3D Framework computational concepts**

<table>
<thead>
<tr>
<th>Test items</th>
<th>Computational concepts in BCTt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Loops</td>
</tr>
<tr>
<td>1 - 6</td>
<td>1. Sequences</td>
</tr>
<tr>
<td></td>
<td>2. Simple loop</td>
</tr>
<tr>
<td></td>
<td>3. Nested loop</td>
</tr>
<tr>
<td></td>
<td>4. IF-then</td>
</tr>
<tr>
<td></td>
<td>5. If-then-else</td>
</tr>
<tr>
<td></td>
<td>6. While</td>
</tr>
<tr>
<td>7 - 11</td>
<td></td>
</tr>
<tr>
<td>12 - 18</td>
<td></td>
</tr>
<tr>
<td>19 - 20</td>
<td></td>
</tr>
<tr>
<td>21 - 22</td>
<td></td>
</tr>
<tr>
<td>23 - 25</td>
<td></td>
</tr>
</tbody>
</table>
**BCTt v.1 Design**

- Self explanatory symbols
- Least possible text
- Emotional connection
- Canvas and maze type

### Example

#### Canvas and Maze Type

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>🐦</td>
<td>🐰</td>
<td>🐯</td>
</tr>
</tbody>
</table>

**Take the chickens with his mother. Beware of the cat.**

Mark the correct sequence:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1x</td>
<td>🐮</td>
<td>🐯</td>
<td>🐯</td>
</tr>
<tr>
<td>2x</td>
<td>🐯</td>
<td>🐮</td>
<td>🐯</td>
</tr>
<tr>
<td>3x</td>
<td>🐯</td>
<td>🐯</td>
<td>🐮</td>
</tr>
</tbody>
</table>
BCTt v.1 Design

Maze A

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

Maze B

1  2  3

4  5  6

7  8  9
If-else example
If-else example
If-else example
If-else example
If-else example
<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Clouds" /> <img src="image" alt="Heart" /></td>
<td><img src="image" alt="Clouds" /> <img src="image" alt="Heart" /></td>
<td><img src="image" alt="Clouds" /> <img src="image" alt="Heart" /> <img src="image" alt="Heart" /> <img src="image" alt="Arrow" /></td>
</tr>
</tbody>
</table>

If-else example
If-else example
BCTt Expert Judgement procedure & results

- 45 experts
- 66 items form

Content validation

- Item difficulty level
- Item relevance to measure CT
- Test length adequacy
- Graphic interface adequacy
- Improvements adequacy: e.g. transitions

Other / suggestions / comments
BCTt Expert Judgement procedure & results

**BCTt item difficulty perceived by experts**

\[ y = 0.1063x + 1.4239 \]

\[ R^2 = 0.8883 \]

**BCTt computational concept relevance to measure CT, perceived by experts**

\[ y = 0.0786x + 3.6857 \]

\[ R^2 = 0.5818 \]

**Test length**

- **adequate**
- **too long**
- **too short**

**Adequacy to evaluate CT**

- **very good**
- **good**
- **intermediate**
- **bad**
- **very bad**

83% → Transitions are positive
“transitions are easily associated to arrows in the answers”

“the allowed paths are clear with transitions, because it excludes diagonal movements”

“In the design without transitions, doubts are generated about when a character reaches another (either when it reaches the previous square or when it reaches the other character square?”

“the test is TOO HARD”

“It is not clear if two chicks can move together after meeting”
BCTt v.2 Design

Form and content modifications

**Oral explanation**

**4 alternative responses**

**If-else reformulation**

**If-then-else reformulation**

Take the chicken with his mother. Pick up the flower on your way. Beware of the cat: don't go through its square.

Mark the correct sequence:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Colour blindness adaptation

Take the chicken with his mother.

Meaning example:

While the chicken is in a triangle, it always moves to the right.

Mark the correct sequence:
### BCTt Administration: participants and procedure

**299 Primary School Students**  
5 to 12 years old

**Action protocol**
Test printed in paper form

**BCTt**

**BCTt variation**

**Transitions**  
No-transitions

<table>
<thead>
<tr>
<th>School</th>
<th>Educational stage</th>
<th>Grades</th>
<th>Students ages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colegio Público Carlos Ruiz</td>
<td>1st</td>
<td>1st and 2nd</td>
<td>5 - 8</td>
</tr>
<tr>
<td>Colegio Los Escolapios</td>
<td>2nd</td>
<td>3rd and 4th</td>
<td>7 - 10</td>
</tr>
<tr>
<td>CEIP León Felipe</td>
<td>3rd</td>
<td>5th and 6th</td>
<td>9 - 12</td>
</tr>
</tbody>
</table>
## BCTt Administration: participants and procedure

<table>
<thead>
<tr>
<th>Educational stage</th>
<th>Grade</th>
<th>Identifier</th>
<th>BCTt</th>
<th>BCTt variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>1</td>
<td>A</td>
<td>A1: n=52</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>B</td>
<td>B1: n=18</td>
<td>B2: n=18</td>
</tr>
<tr>
<td>2nd</td>
<td>4</td>
<td>C</td>
<td>C1: n=54</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>D</td>
<td>D1: n=28</td>
<td>D2: n=28</td>
</tr>
<tr>
<td>3rd</td>
<td>5</td>
<td>E</td>
<td>E1: n=51</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>F</td>
<td>F1: n=25</td>
<td>F2: n=25</td>
</tr>
</tbody>
</table>

- **Time 1**: A1, B1, C1, D1, E1, F1
- **Time 2**: 5 weeks later, B2, D2, F2
- **BCTt variation**: A, B, C, D, E, F
- **Procedure**:
BCTt Administration: results

**Student’s t-test**

Significant difference in test scores (p=0.005< 0.01) in lower grades

<table>
<thead>
<tr>
<th>Sample</th>
<th>Entire sample</th>
<th>A1</th>
<th>B1</th>
<th>C1</th>
<th>E1</th>
<th>F1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td>1-6</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>N</td>
<td>200</td>
<td>52</td>
<td>18</td>
<td>54</td>
<td>51</td>
<td>25</td>
</tr>
<tr>
<td>Mean</td>
<td>19.92</td>
<td>16.52</td>
<td>16.78</td>
<td>21.57</td>
<td>21.84</td>
<td>21.72</td>
</tr>
<tr>
<td>Median</td>
<td>20.00</td>
<td>16.00</td>
<td>18.00</td>
<td>23.00</td>
<td>23.00</td>
<td>22.00</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>3.79</td>
<td>3.31</td>
<td>2.49</td>
<td>3.044</td>
<td>2.61</td>
<td>2.62</td>
</tr>
<tr>
<td>Minimum</td>
<td>8.00</td>
<td>8.00</td>
<td>11.00</td>
<td>14.00</td>
<td>13.00</td>
<td>15.00</td>
</tr>
<tr>
<td>Maximum</td>
<td>25.00</td>
<td>24.00</td>
<td>20.00</td>
<td>25.00</td>
<td>25.00</td>
<td>25.00</td>
</tr>
<tr>
<td>Percentiles</td>
<td>25</td>
<td>17.00</td>
<td>14.00</td>
<td>15.75</td>
<td>19.00</td>
<td>20.00</td>
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<tr>
<td></td>
<td>50</td>
<td>20.00</td>
<td>16.00</td>
<td>18.00</td>
<td>23.00</td>
<td>23.00</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>23.00</td>
<td>19.00</td>
<td>18.00</td>
<td>24.00</td>
<td>24.00</td>
</tr>
</tbody>
</table>
BCTt Administration: results

Item analysis

Computational concept by grade

Item difficulty index for each BCTt item

Item difficulty index
### BCTt Administration: results

<table>
<thead>
<tr>
<th>Sample</th>
<th>Reliability Statistics</th>
<th>Item Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Cronbach 's Alpha</strong></td>
<td><strong>Cr. 's Alpha</strong></td>
</tr>
<tr>
<td></td>
<td>Based on Stand. Items</td>
<td>Based on Stand. Items</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td><strong>N of Items</strong></td>
<td><strong>Cronbach 's Alpha</strong></td>
</tr>
<tr>
<td>200</td>
<td>25</td>
<td>0.824</td>
</tr>
</tbody>
</table>

### Subsamples

<table>
<thead>
<tr>
<th>Ed. stage</th>
<th>Grade</th>
<th>Id.</th>
<th>n</th>
<th>Cronbach 's Alpha</th>
<th>Cr. 's Alpha Based on Stand. Items</th>
<th>Item Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st</td>
<td>1</td>
<td>A1</td>
<td>52</td>
<td>0.833</td>
<td>0.838</td>
<td>0.742 0.041</td>
</tr>
<tr>
<td>1st</td>
<td>2</td>
<td>B1</td>
<td>18</td>
<td>0.793</td>
<td>0.801</td>
<td>0.630 0.042</td>
</tr>
<tr>
<td>2nd</td>
<td>4</td>
<td>C1</td>
<td>54</td>
<td>0.771</td>
<td>0.735</td>
<td>0.837 0.022</td>
</tr>
<tr>
<td>3rd</td>
<td>5</td>
<td>E1</td>
<td>51</td>
<td>0.660</td>
<td>0.683</td>
<td>0.863 0.012</td>
</tr>
<tr>
<td>3rd</td>
<td>6</td>
<td>F1</td>
<td>25</td>
<td>0.657</td>
<td>0.648</td>
<td>0.844 0.015</td>
</tr>
</tbody>
</table>

Task and re-task method
(D1 subsample)
Non-parametric Spearman’s test

very strong significant correlation
(rs=0.93; p<0.01).
Conclusions

✓ BCTt is adequate for the assessment of CT in Primary School

✓ Transitions between maze squares are a relevant improvement for young students

✓ BCTt seems to be aimed at 1st to 4th grades (5 to 10 years old)

✓ Reliability is high and higher in younger students

✓ Recommended to use in parallel with other tools → system of assessments

3D Framework

- CT concepts
- CT practices
- CT perspectives
Conclusions

✓ It could be used as a pre-test / post-test instrument

Blue Ant Code (Android and IOs)
Conclusions

✓ BCTt lower limit

✓ Other countries: Portugal, Chezch republic, Germany, France, ...

✓ Populations

✓ BCTt new version → Cornell University NY
Thank you very much for your time!

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