Principled Assessment of Computational Thinking

Measuring CT Concepts, Practices and Perspectives Through Evidence-Centered Assessment

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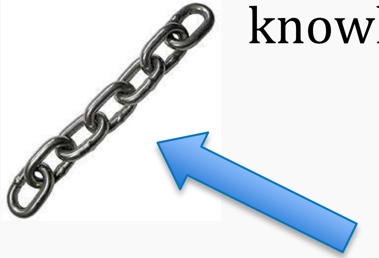
Propositions

- Computational thinking curricula are growing quickly
  => Stakeholders want to know if they're effective
- Assessments have not yet kept pace
  => And they're hard to develop
- Principled Assessment Design can help

Principled Assessment Design: Developing a chain of evidence

Claims about students' knowledge and skills



What students do

Design pattern

Overview

Computational Thinking

Measuring Computational Thinking Outcomes

Assessment Arguments & Evidence-Centered Design (ECD)

ECD Applications

- *PACT*
- *CoolThink@JC*

Closing Comments

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Computational Thinking

Computational Thinking

Wing (2006, 2011) defined computational thinking as the **thought processes** involved in **formulating problems and their solutions** so that the solutions are represented in a form that can be **effectively carried out by a computer**.

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Computational Thinking

Grover & Pea (2013) identified these features of CT in their extensive literature review:

- abstractions and pattern generalizations
- systematic processing of information
- symbol systems and representations
- debugging and systematic error detection

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Computational Thinking

Workforce studies (e.g., Malyn-Smith & Lee, 2012) indicate CT involves **collaborating** and **engaging in a creative process** to:

- solve problems
- design products
- automate systems
- improve understanding by defining, modeling, qualifying and refining systems

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Computational Thinking

Brennan and Resnick’s (2012) framework divides CT into three interrelated areas:

- CT Concepts >>> CS content knowledge
- CT Practices >>> logical thinking/problem solving skills
- CT Perspectives >>> interest, motivation, self-efficacy

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Computational Thinking Practices

“Ways of being and doing” that students should demonstrate when learning and exhibiting computer science knowledge, skills, and attitudes

- Algorithmic thinking
- Reusing & remixing
- Testing & debugging
- Abstracting & modularizing

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Measuring CT Outcomes

Impacts of CT Curricula?

Despite the proliferation of CT-focused programs, there is still a lack of strong empirical studies that examine the impact of curricula on students' CT learning outcomes.

- Lye and Koh (2014): only 27 studies examining computational thinking skills as outcomes
- Challenge for teachers: locating valid and reliable assessments of computational thinking for their classrooms

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Assessment Arguments & Evidence-Centered Design

Assessment Questions

What knowledge, skills, or other attributes should be assessed?

>>> *What do we want students to know and be able to do?*

What behaviors or performances should reveal those attributes?

>>> *What counts as evidence?*

What tasks or situations should elicit those behaviors?

>>> *How do we get students to produce that evidence?*

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Evidence-Centered Assessment Design

ECD is a framework for assessment design and development.

Views assessment as a process of gathering evidence to support an argument about what a student knows and can do.

Provides a structure for an approach that incorporates validity evidence into the assessment design process.

Particularly useful when the knowledge/skills to be measured involve complex, multistep performances, such as those required in computational thinking.

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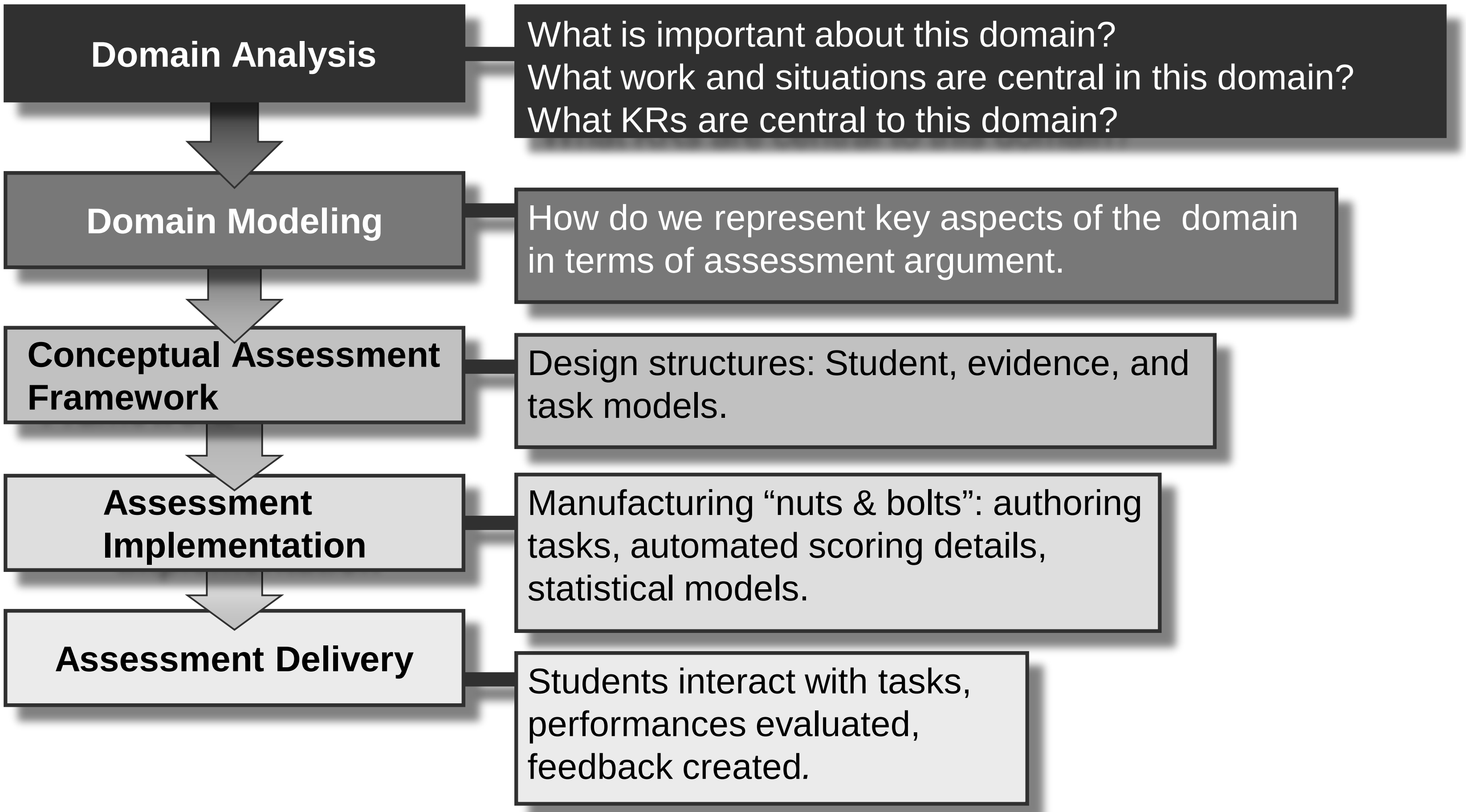

- From Mislevy & Riconscente, 2006

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Applications of Evidence-Centered Design

Principled Assessment of Computational Thinking

ECS | Exploring Computer Science

Principled Assessment of Computational Thinking (PACT)

Create design templates for supporting CT assessment development for secondary CS.

>>> ***Computational Thinking Design Patterns***

Design, develop, validate assessments of computational thinking practices aligned with the ECS curriculum.

What's in a design pattern?

Focal Knowledge, Skills, and other Attributes (FKSAs)	Specific knowledge and skills that we want to make inferences about
Additional KSAs	Other knowledge and skills that may be required for successful performance, but aren't what we're trying to measure
Potential observations	Features of the things students say, do, or make that constitute evidence of their performance
Potential work products	Artifacts of the student's performance we can see
Characteristic features	Aspects of assessment situations that will evoke the desired evidence or are required to support the task
Variable features	Aspects of assessment situations that can be varied in order to shift difficulty or emphasis

Design and implement creative solutions and artifacts

Focal Knowledge, Skills, and other Attributes (FKSAs)	• Ability to state a problem in order to identify its inputs and outputs • Ability to decompose a problem into multiple subproblems, and specify how solving one subproblem will help generate a solution to the problem as a whole • Ability to create a computational artifact given a purpose or intent • …
Additional KSAs	• Knowledge of a specific programming language

Design and implement creative solutions and artifacts

Potential observations	• Degree to which the solution is related to the identified purpose • Degree to which the solution addresses the problem • Level of complexity of the solution • …
Potential work products	• Description of the design process • Computational solution • Description or explanation of the solution • Description of the debugging process • Trace of the debugging process • …

Computational Thinking Design Patterns

Analyze the effects of developments in computing

Design and implement creative computational solutions and artifacts

Design and apply abstractions and models

Analyze computational work (both own and others)

Communicate computational thought processes, procedures and results to others

Collaborate with peers on computing activities

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Bringing computational thinking to Hong Kong students in Primary 4-6.

Target outcomes based on Brennan and Resnick (2012) CT Framework:

>>> ***CT Concepts, CT Practices, CT Perspectives***

SRI used ECD to develop student assessments and a survey that are aligned with these outcomes.

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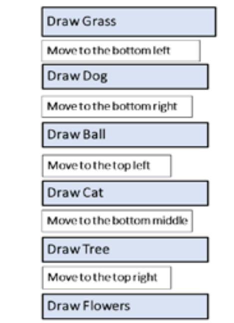
>>> ***Specified focal knowledge and skills aligned with CT Practices***

CT Practices	Focal Knowledge & Skills
Algorithmic Thinking: Articulating a problem solution in well-defined rules and steps	1. Ability to state a problem in terms of what is given and what the end result should be 2. Ability to recognize and define computational problems 3. Ability to create a specification for the implementation of a solution 4. Etc.

Darren wants to create a program to draw the following picture:

Darren uses the following steps to make the program. He finds that some things are not in the correct place.

- Draw Grass
- Move to the bottom left
- Draw Dog
- Move to the bottom right
- Draw Ball
- Move to the top left
- Draw Cat
- Move to the bottom middle
- Draw Tree
- Move to the top right
- Draw Flowers



b. Put the steps in order so that they will put all of the things in the correct place. You can move the steps by dragging each block into the space provided.

Draw Grass

Draw Ball

Draw Cat

Draw Dog

Draw Flowers

Draw Tree

Move to the bottom middle

Move to the bottom left

Move to the bottom right

Move to the top right

Move to the top left

a. Put a check mark in front of the things that are not in the correct place.

- ☐ Dog
- ☐ Ball
- ☐ Cat
- ☐ Tree
- ☐ Flowers

Closing Comments

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Growing consensus on facets of computational thinking.

Validated measures of CT outcomes are needed to provide stakeholders with high-quality evidence of student learning.

ECD is particularly relevant when the knowledge/skills to be measured involve complex, multistep performances, such as those required in computational thinking.

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Links for more information

ECD: https://ecd.sri.com/

PACT: https://pact.sri.com/

Design patterns: http://bit.ly/2u6t0Nw

ECS assessments and rubrics: https://pact.sri.com/ecs-assessments.html

Thank you!