Computer Science in Secondary Schools (CS3): Studying Context, Enactment, and Impact

SRI Education

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Principled Assessment of Computational Thinking

Research Questions

1. How and why do teachers implement the inquiry- and collaboration-based instructional strategies (IBIS, CBIS) supported in the ESC program?
2. How, why, and to what extent do teachers adapt the ECS curriculum materials?
3. How does implementation relate to student outcomes? What factors enhance or impede the successful implementation of ECS?

Research Plan

The CS3 project involves two broad strands of work.

- Assessing student learning outcomes requires the team to develop validated measures of students' proficiency with computational thinking practices
- Characterizing the relationship between curriculum implementation and student learning outcomes requires an analysis integrating teacher and learning context attributes, teaching approaches, and curriculum adaptation

Core Constructs

- Teaching Quality
- Curriculum Enactment
- Teacher and Learning Context Attributes

Analysis

Our analysis will link indicators of TQ and CE along with key attributes of the ECS teachers and learning contexts. We explore the impact of these key indicators and attributes on student computational thinking outcomes, as measured by assessments for ECS Units 1 to 4, as well as a pretest and a cumulative posttest.

Samples

Region	Teacher n	Student n
Western	3	85
Midwestern-Urban	24	934
Midwestern-Rural	20	415
Total	47	1434

Teacher Background, PD & Unit Surveys / Student Assessments

Data Collection Activity	Teacher n	Student n
Background Survey	36	NA
PD Survey	11	NA
Pre Assessment	NA	1133
ECS Unit 1	38	981
ECS Unit 2	37	892
ECS Unit 3	27	811
ECS Unit 4	28	586
Cumulative Assessment	NA	780

Relating Instructional Strategies, Curriculum Adaptations and Student Success

Instructional Strategies

Below are some examples of how the CS3 team measured inquiry- and collaboration-based instructional strategies (IBIS, CBIS). We measured these constructs by asking teachers about their typical experiences in a background survey, and then asking them about their specific implementation experiences in a series of unit surveys.

We operationalized IBIS and CBIS as combinations of a teacher's instructional practices with the perceived success of CT promotion strategies related to those practices. We have included examples of survey questions in each area below.

Inquiry-Based Instructional Strategies (IBIS)

Inquiry-Based Practices + Perceived Success of CT Promotion Strategies Related to Inquiry

When teaching Unit XX, how often did you engage students in the following practice?

- Students identify questions to answer or problems to solve
- Students develop their own solutions to problems

Which of the following were successful in promoting computational thinking in your ECS classroom during Unit XX?

- Opportunities for students to solve challenging problems
- Opportunities for students to create computational artifacts or products

Levels	N of Teachers			
	Unit 1	Unit 2	Unit 3	Unit 4
L1: No practice regardless of Success	0	0	0	0
L2: Low frequencies of practice + Few success	3	2	0	0
L3: Low frequencies of practice + More success	5	4	1	1
L4: High frequencies of practice + Few success	12	7	8	5
L5: High frequencies of practice + More success	17	22	18	22
Total	**37**	**35**	**27**	**28**

Interpretation

- High IBIS levels across all ECS units, with units 3 and 4 having the highest levels.
- Some teachers transitioned from lower IBIS levels to higher IBIS levels as they progressed from unit 1 to unit 4, likely due to the nature of the different unit topics and activities.

Collaboration-Based Instructional Strategies (CBIS)

Collaboration-Based Practices + Perceived Success of CT Promotion Strategies Related to Collaboration

When teaching Unit XX, how often did you engage students in the following practice?

- Students collaborate or work in teams
- Students engage in reflection and discussion
- Students present or communicate their ideas to peers

Which of the following were successful in promoting computational thinking in your ECS classroom during Unit XX?

- Opportunities for students to work collaboratively
- Opportunities for students to share their computational thinking with peers

Levels	N of Teachers			
	Unit 1	Unit 2	Unit 3	Unit 4
L1: No practice regardless of Success	0	0	0	0
L2: Low frequencies of practice + Few success	4	4	4	5
L3: Low frequencies of practice + More success	1	3	5	4
L4: High frequencies of practice + Few success	7	5	5	3
L5: High frequencies of practice + More success	25	23	13	16
Total	**37**	**35**	**27**	**28**

Interpretation

- High CBIS levels across all ECS units, but less so than IBIS levels. ECS units 1 and 2 had the highest CBIS levels.
- Some teachers transitioned from higher CBIS levels to lower CBIS levels as they progressed from unit 1 to unit 4, likely due to the nature of the different unit topics and activities.

Curriculum Adaptation

	Modifying Unit Topics	Adding Unit Topics	Skipping Unit Topics
Higher prior IBIS and CBIS levels	More Likely	n.s.	n.s.
More experience teachers have with teaching CS	Less Likely	n.s.	n.s.
More CS courses that were offered at a school	Less Likely	n.s.	n.s.
A lack of necessary equipment, technical difficulties with software	n.s.	More Likely	More Likely
Better condition of and access to technology, IT support at a school	Less Likely	n.s.	n.s.

Interpretation

- Teachers with prior experience with focal ECS instructional strategies (e.g. IBIS, CBIS) appear to be more inclined to modify units, perhaps because those strategies often require teachers to customize materials, so they are comfortable doing so.
- If there is some kind of well-established CS program at the school (as evidenced by CS teaching experience or other CS classes,) then teachers are more likely to implement lessons "as-is". Additional evidence is needed to help understand why.
- Access to technology matters for how lessons are implemented. If teachers lack technology, or experience software issues, they tend to skip or replace certain lessons. If teachers have access to technology, they tend to use the curriculum more "as-is".

Student Success by Covariates & Mediating Factors (adjusting for performance on pre-test)

- Students whose teachers reported higher unit IBIS or CBIS performed significantly better on the assessments for two of the units:
  - Higher level of CBIS was related to better performance on Unit 1 (human- computer interaction)
  - Higher level IBIS was related to better performance on Unit 3 (web design)
- Students whose teachers reported more experience teaching Computer Science courses performed significantly worse on the ECS unit assessments across all units.
- Students whose teachers reported more experience teaching ECS courses performed better on the ECS unit 2 assessment (problem solving).
- Students whose teachers reported a higher number of CS courses at the school performed significantly better on the ECS unit 1 assessment but not for the other three units.

Interpretation

- The relationship between instructional strategies and student performance varies by ECS unit.

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Exploring Computer Science

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