# External Evaluation of the iSTEM CS Computational Thinking Grant

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## Assessment Overview

*CS for SC: A Landscape Report of K-12 Computer Science in South Carolinas* (Burke, Quinn & Schep, Madeleine & Dalton, Travis, 2017) examined the current state of computing education on the K-12 level within the state of South Carolina. This research was funded through a generous grant through the National Science Foundation Broadening Participation in Computing Alliance (NSF Award No. 1228352, 1228355) administered through Expanding Computing Education Pathways (ECEP).

The report drew the following conclusions about computer science in South Carolina:

- A wide range of educators in terms of academic discipline, are interested in incorporating computing into their existent coursework, focusing particularly on introductory activities through programs like Scratch and App Inventor and curricula like Exploring Computer Science.
- There is a general lack of geographical diversity in terms of where computing coursework is offered state-wide, with the majority of respondents (72%) from the state's largest three cities.
- A high percent (81%) of South Carolina schools use national models (e.g., Google CS First/ Project Lead the Way) for their computing curricula.
- There is a lack of economic diversity in terms of where computing coursework is offered statewide, with only a fraction of the state's Title I schools reporting to offer such curricula.

In 2017, Boeing SC provided funding to begin a pilot study for integrating computational thinking (CT) into South Carolina middle school science and mathematics instruction. The program itself was entitled *iSTEM CS - Integrating Computational Thinking into STEM Learning* abbreviated as "iSTEM-CS". The stated purpose of the iSTEM-CS program was to serve as a "pilot effort to develop an instructional leadership experience for science, technology, engineering, mathematics (STEM) interested educators preparing to integrate South Carolina Computer Science and Digital Literacy Standards, with emphasis on computational thinking, into existing content courses."

Overall the iSTEM-CS program worked primarily with public middle level students from underserved populations in Berkeley, Colleton, Dorchester, and Jasper counties. Additionally, the program sought to improve/increase interest and participation in CT by female students.

The primary objectives for this pilot study were:

- teachers will measurably improve their instructional design skills in developing lessons that integrate CT concepts into their subject area as measured by $S^2$TEM Centers SC instructional analysis.
- teachers will measurably improve their instructional skills in delivering CT standards as measured by $S^2$TEM Centers SC instructional coach classroom observations.
- teachers increase personal understanding of CT as measured by SRI's Principled Assessment of Computational Thinking (PACT).

Teacher Participant Training took place over seven days (spread out) beginning in January 2018 and ending in 2019. In addition to this intensive whole group learning experience, each participant worked with an on-site instructional coach who aided and supported the teacher throughout the process. These on-site coaches were also responsible for administering and/or completing the various assessment instruments.

The assessment system for iSTEM-CS consisted of four principal instruments that were administered early in the program and then at the end of the program. These instruments were:

- ✓ Teacher Reported Demographics – These data indicated the number of students being taught by each teacher grouped by gender and ethnicity.
- ✓ Participant/Teacher Survey – The teacher survey assessed interest in CT; familiarity with key terms in CT; knowledge of computational thinking skills; analysis of selected teaching scenarios in terms of decomposition, abstraction, pattern recognition and algorithmic design; and personal comments regarding their own knowledge and use of CT.
- ✓ Reformed Teaching Observation Protocol (RTOP) – This was an on-site observation protocol conducted by each teacher's $S^2$TEM Centers instructional coach with advance preparation and coaching input. Coach/observers looked for the demonstration of each of fifteen CT criteria. Coaches also provided written assessments of the demonstration lesson both to assist the teacher and provide assessment data.
- ✓ Student Survey -- Students were asked to rate a variety of areas of intellectual/career fields and indicate how often they participated in a variety of CT related activities.

This report will take each of these assessment components and discuss the data and what they revealed about the teachers, students and program.

## Student Class Demographics as Reported by Teachers

Each participating teacher was asked to report relevant demographic data regarding the students enrolled in their CT-related classes. No ethnic data was reported for 2017-2018. It is important to note that in some schools, a student might be attending classes taught by more than one iSTEM-CS teacher. The proportions represented by the data below are representative of student diversity in the classes involved in the iSTEM-CS program. In spite of any redundancy or omissions, the data demonstrate that the populations served by this project were diverse ethnically and by gender.

### Students Taught in 2017/2019 by Gender and Ethnicity

| | Number of Students | | |
|---|---|---|---|
| | | 2017/2018 | 2018/2019 |
| African American | | | |
| | Male | | 301 |
| | Female | | 206 |
| Hispanic | | | |
| | Male | | 118 |
| | Female | | 104 |
| All | | | |
| | Male | 717 | 896 |
| | Female | 678 | 736 |

## iSTEM-CS Teacher Survey

A major expectation for the participating teachers was that they would significantly improve their knowledge and understanding of computational thinking. The stated goal was that “teachers [would] increase personal understanding of CT as measured by SRI's Principled Assessment of Computational Thinking (PACT). This goal was assessed in four elements of the iSTEM-CS Teacher Survey. Each participant teacher was given both an initial and final survey to determine their:

1. interest in CT
2. familiarity with key terms in CT
3. knowledge of computational thinking skills, analysis of selected teaching scenarios in terms of decomposition, abstraction, pattern recognition and algorithmic design and
4. personal comments regarding their knowledge and use of CT.

These data elements were collected from a paper document and transferred to on on-line survey instrument.

All teachers and classes instructed one or more of the typical middle school grades (6-8). The teachers covered the following subjects:

| Subject | Number of Teachers |
|---|---|
| Science | 9 |
| Mathematics | 11 |
| English/Language Arts | 1 |
| Other | 1 |

### <u>Element 1 – Teacher interest in and comfort with CT concepts</u>

The survey included a list of statements about computing with which teachers could agree or disagree. Four of the (agree – disagree) statements on the list in particular are good indicators of participant understanding and acceptance of the overall concept and importance of computational thinking. Below are the statements and the patterns in the initial/final surveys. Note that in each case, the post assessment shows a much stronger more positive belief about and confidence in the importance of computational thinking.

1. “The challenge of solving problems using computer science appeals to me.”

| | % Initial | % Final |
|---|---|---|
| Strongly Disagree | | |
| Disagree | 30 | 15 |
| Agree | 60 | 45 |
| Strongly Agree | 10 | 35 |

2. “I use computational thinking skills in my daily life.”

| | % Final (new item on final only) |
|---|---|
| Strongly Disagree | |
| Disagree | 5 |
| Agree | 65 |
| Strongly Agree | 30 |

3. “Having background knowledge of computer science is valuable.”

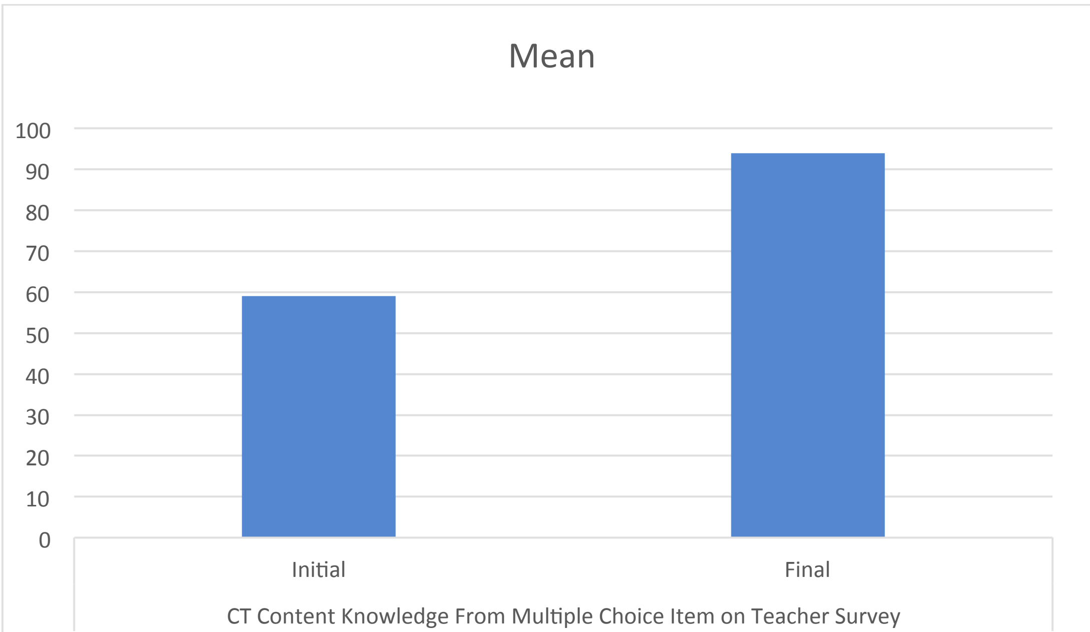
| | % Initial | % Final |
|---|---|---|
| Strongly Disagree | 5 | |
| Disagree | 10 | |
| Agree | 75 | 45 |
| Strongly Agree | 10 | 55 |

4. “I can learn to implement computing concepts in my classroom.”

| | % Initial | % Final |
|---|---|---|
| Strongly Disagree | | |
| Disagree | 20 | 5 |
| Agree | 60 | 35 |
| Strongly Agree | 20 | 50 |

**Element 2 – Teacher knowledge of essential terms and concepts of CT**

Teacher content knowledge of the important terms in CT was assessed using a nine-item matching type item. It should be noted that while the item itself could have been more strongly constructed, it did serve to demonstrate teacher familiarity with these terms. The chart below shows that the mean for all teachers on the initial evaluation was just short of 60%. After training the mean was about 95%. In fact, the mode (the most frequently occurring score) on the final was 100%. Overall, it is safe to conclude that almost all of the teachers were very familiar with essential CT terms by the completion of this pilot.




**Element 3 – Analysis of selected scenarios**

Teachers were given four CT related CT problem scenarios to analyze before and after the iSTEM-CS program. Each scenario asked for evidence and explanations for how the primary CT concepts (decomposition, abstraction, pattern recognition and algorithmic design) could be used to respond to the scenario. No teacher responded to the scenarios on the first survey administration. This was probably due to a combination of unfamiliarity with the concepts, unclear directions, and/or limited time to complete the form. All teachers were able to provide clear and appropriate responses to each scenario on the final survey. Even though participants had limited space for responses, some of the responses, however, were more elaborate than others. These improved responses provide strong evidence that almost all participant teachers had at least a basic understanding of these key CT concepts. The results support the modest assumption that these teachers would now be able to recognize, use and even teach these concepts in their own classrooms.

**<u>Element 4 -- Personal comments regarding their knowledge and use of CT</u>**

Part of the assessment of teacher integration of classroom related CT concepts into various subject areas was to ask each participant to respond to two questions upon completing the program. The selected responses below indicate that the teachers did indeed "get it." Their responses display a wide variety of applications and strategies.

***Prompt 1: What are you currently doing to enact computational thinking in your classroom?***

Every teacher listed at least one application and most listed several examples of integration. As can be seen from the responses below, teachers used a wide variety of applications.

> story boards, algorithms, coding ozbots, passion project, problem-based learning, games
>
> currently creating and planning breakouts with students to go through CT in lessons
>
> Break out (digital), pattern recognition & decomposition in word problems, algorithmic thinking for multi-step problems.
>
> We are currently using decomposition to break down elements of the novel <u>War Horse</u> [in English].
>
> I'm using coding such as "code your world", scratch, Google CS and SNAP cellular. Additionally, I have used Ozbots and plan to use Raspberry PI's in the future.
>
> Students are using practices to solve problems that weren't typically explained using textbooks.
>
> Problem solving in most lessons requires abstraction, decomposition, pattern recognition. We break down problems into their basic parts. We routinely look for a pattern and use a set of steps for a known type of problem.
>
> I engage students through learning by discovery and problem solving in which they use the 4 cornerstones (unknowingly) to learn new topics. I have used flowcharting, break-out games, pattern recognition, algorithm design, cartoon creation and other methods.

I encourage computational thinking by having students take ownership for their learning through student directed activities that include choice and technology.

… using more graphic organizers -- algorithmic design; I always have the students look for patterns -- pattern recognition; I teach the students to discern which information might be superfluous -- abstraction.

Decomposition -- breaking down problems into smaller pieces. Abstraction -- eliminating non-essential information, Pattern recognition -- look for patterns in solving problems. Flow charting -- story boarding and breakouts.

I am challenging my students to take complex problems and break them down into more manageable steps. The can weed out what is not important to hopefully gain a better understanding.

In my classroom, I am being intentional about introducing the language of computational thinking. I have also implemented processes like flowcharting, storyboarding, digital games and productive struggle.

I am trying to bring in more technology into the classroom. My students do use Deck Toys in one of my stations. I also try and get my students familiar with using storyboards to help with explaining a mathematical process.

***Prompt 2: How does using computational thinking strategies enhance student learning in your area?***

Since every participant offered one or more strategy, a quick read of these entries shows that the participants definitely felt that their students were benefiting from their (the teachers) use of CT strategies.

1. Makes them think about their thinking, 2. They slowed down and think about a process instead of rushing through to get an answer, 3. Teaches them lifelong skills that will help them through school and life.

It has the students engaged and thinking deeper and processing at a new level. It gets them problem solving!

It helps students to break down a problem & determine what is necessary to successfully answer questions.

They look at concepts and lessons differently -- from a more scientific way of thinking. Computational thinking encourages students to problem solve.

Using flow chart symbols to represent steps in lab report.

1. Having the vocabulary to identify the process allows for quicker recognition of what's needed. 2. They're used to [help] struggling [students] so they don't give up as quickly. 3. Higher success with story problems.

When students learn by discovery and not simple memorization, they understand and retain more of the subject matter. Students become focused on research and problem solving in science, and they more readily recognize patterns and create algorithms in math.

These strategies create better problem-solving skills and encourage perseverance on difficult tasks. Using these strategies gives the students more control over their learning. allows the students to breakdown a large complex idea into smaller sections in a logical manner.

Thinking more in depth about solving problems. In science students follow the scientific method/science & engineering practices to follow labs/solving problems.

Computational thinking requires students to think more critically to solve a task. This creates more meaningful learning for the students.

It forces students to think outside the box and creatively work through a variety of issues. Also, understanding and practicing with technology can open doors for the future.

Allows peer group interaction, helps students recognize/recall info and use them for new material, recognizing patters, algorithm, being able to decompose info.

The students get a break from standard classroom flow which naturally creates interest. They tend to remember the lesson more even if there as frustration in the process.

Computational thinking helps students to break down the process in steps. In math, many steps have to be taken to solve one problem. Breaking it down can allow the students to be able to explain the process better.

## Reformed Teaching Observation Protocol (RTOP) Data

Each teacher participant was observed twice (soon after training and at the end of the program) using an assessment instrument called the Reformed Teaching Observation Protocol (RTOP- see Appendix for RTOP form). Trained observers from the $S^2$TEM Centers were asked to rate participants on each of 15 criteria using this protocol. For example, they were asked to determine if "This lesson encouraged students to seek and value *alternative modes* of investigation or of problem solving using Computational Thinking processes." Each process was rated on a scale ranging from "Not Observed" to "Trait Mastered." Additionally, observers provided qualitative observations of the lessons relative to the use computational thinking. Both the ratings and the comments were analyzed and the results summarized below.

The RTOP data was collected to determine the accomplishment of two program goals:

1. Teachers will measurably improve their instructional design skills in developing lessons that integrate CT concepts into their subject area as measured by $S^2$TEM Centers SC instructional analysis.
2. Teachers will measurably improve their instructional skills in delivering CT standards as measured by $S^2$TEM Centers SC instructional coach classroom observations.

Prior to each presentation, participating teachers prepared formal lesson plans to match their presentation. These lesson plans were vetted by the instructional coaches and those plans that were approved are currently available on line. The final lessons (lesson plans and video recordings thereof) have been archived and made available on line for use by other teachers and/or trainers.

REFORMED TEACHING OBSERVATION PROTOCOL (RTOP)

| | | | |
|---|---|---|---|
| Teacher # | | Observer | |
| School # | | Date | |
| Pre/Post/Other | | | |

Lesson Design and Implementation

The Lesson Plan (if applicable) incorporated implementation of (check all that apply):

- Pattern Recognition (looking for similarities among and within problems)
- Decomposition (breaking down a complex problem or system into smaller, more manageable parts)
- Algebraic Thinking (developing a step-by-step solution to the problem, or the rules to follow to solve the problem)
- Abstraction (focusing on the important information only, ignoring irrelevant detail)

| Q# | Criteria | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | This lesson encouraged students to seek and value *alternative modes* of investigation or of problem solving using Computational Thinking processes. | 0 | 1 | 2 | 3 | 4 | |
| 2 | Students *were actively engaged* in thought-provoking activity that often involved the critical assessment of CT procedures. | 0 | 1 | 2 | 3 | 4 | |
| 3 | The teacher's *knowledge of CT* triggered *divergent* modes of *thinking.* * | 0 | 1 | 2 | 3 | 4 | |
| 4 | There was a *high proportion of student talk around CT* and a significant amount of it occurred between and among students. | 0 | 1 | 2 | 3 | 4 | |
| 5 | Students made predictions, estimations and/or hypotheses and devised means of testing them. | 0 | 1 | 2 | 3 | 4 | |
| 6 | Students *used* CT strategy(ies) to represent phenomena. | 0 | 1 | 2 | 3 | 4 | |
| 7 | Connections with other content disciplines and/or real-world phenomena were explored and valued. | 0 | 1 | 2 | 3 | 4 | |
| 8 | The CT strategy(ies) were used appropriately. | 0 | 1 | 2 | 3 | 4 | |
| 9 | The lesson involved *fundamental concepts* of CT. | 0 | 1 | 2 | 3 | 4 | |
| 10 | The lesson promoted strongly *coherent conceptual understanding* of CT. | 0 | 1 | 2 | 3 | 4 | |
| 11 | The teacher had a *solid grasp* of CT content inherent in the lesson. | 0 | 1 | 2 | 3 | 4 | |
| 12 | Elements of *pattern recognition* were encouraged *when it was important to do so (if planned for in the lesson).* | 0 | 1 | 2 | 3 | 4 | n/a |
| 13 | Elements of *decomposition* were encouraged *when it was important to do so (if planned for in the lesson).* | 0 | 1 | 2 | 3 | 4 | n/a |
| 14 | Elements of *algebraic thinking* were encouraged *when it was important to do so (if planned for in the lesson).* | 0 | 1 | 2 | 3 | 4 | n/a |
| 15 | Elements of *abstraction* were encouraged *when it was important to do so (if planned for in the lesson).* | 0 | 1 | 2 | 3 | 4 | n/a |
| | Subtotals | | | | | | |
| | Total Score | | | | | | |

REFORMED TEACHING OBSERVATION PROTOCOL (RTOP)

| | | | |
|---|---|---|---|
| Teacher # | | Observer | |
| School # | | Date | |
| Pre/Post/Other | | | |

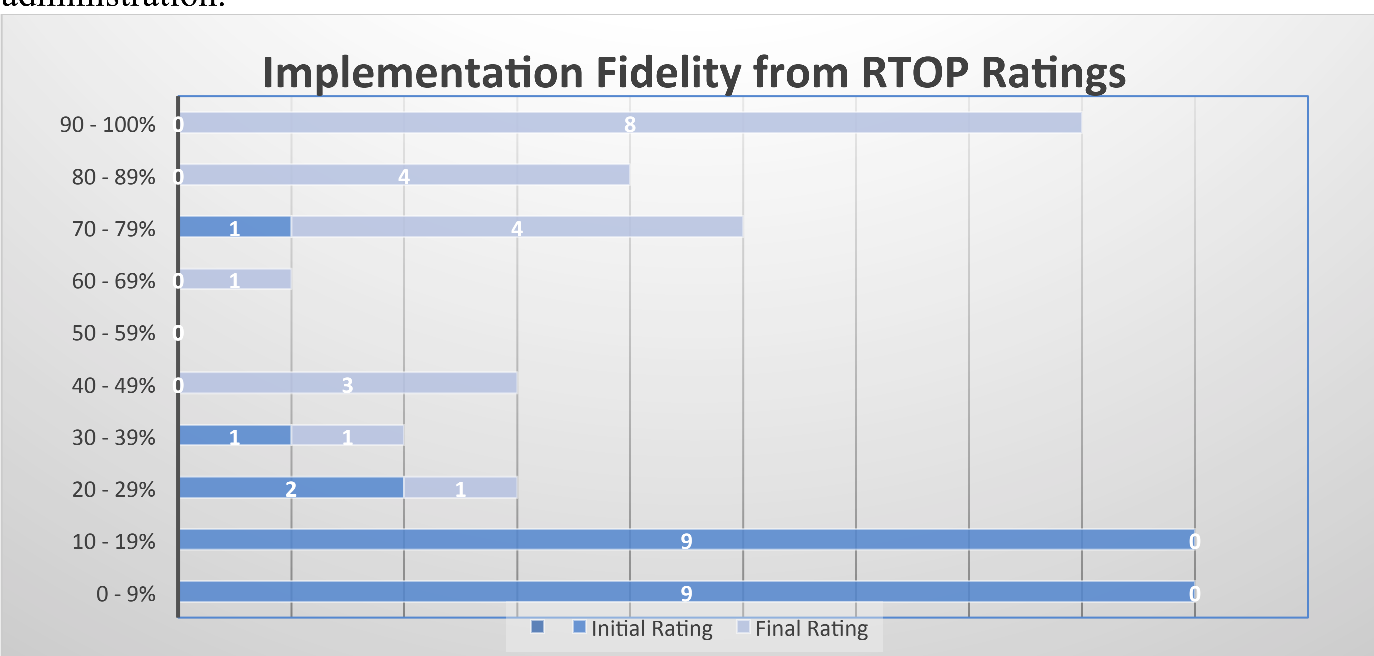
Qualitative Observations

Be sure to include information about the following classroom components:

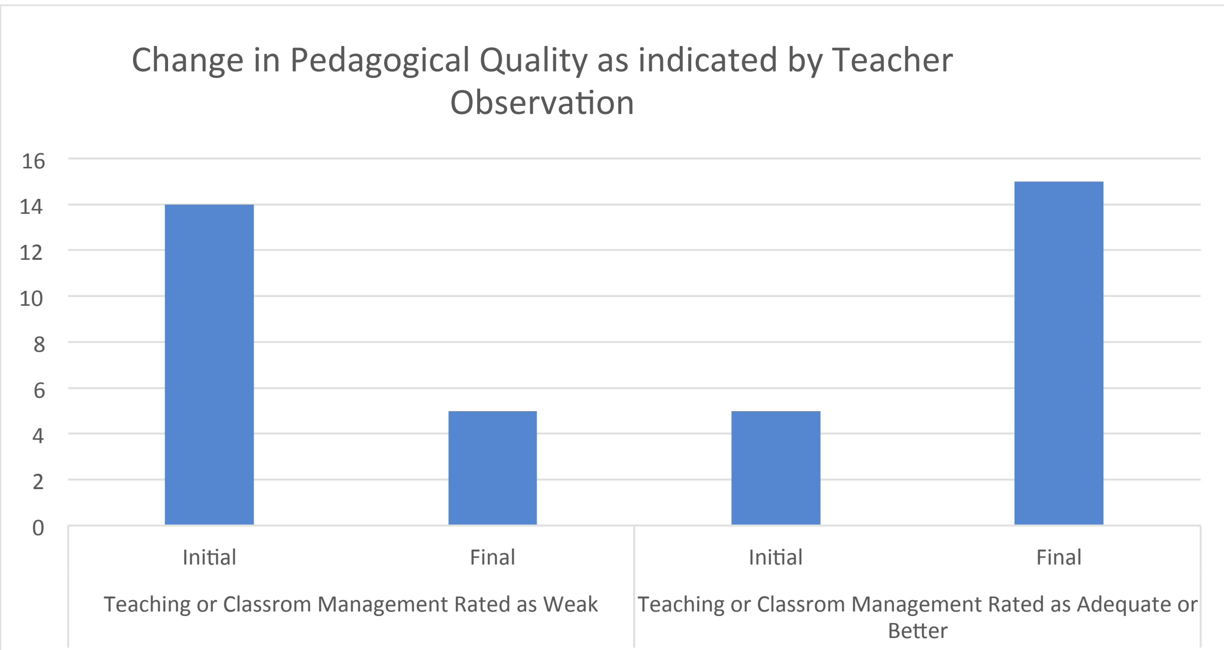
- Collaborative Environment (specifically the sharing of ideas and changing ideas based on others' thoughts)
- DOK & Pedagogy (Specifically problems with content or teaching or classroom management)
- Student Reflection (specifically time, metacognition and depth of questioning)
- Teachers ability to changing direction based on student interest and need

## **<u>Analysis of the 15 RTOP Criteria Ratings</u>**

During and after each teacher's lesson, the observer rated CT components of the lesson based on the 15 RTOP criteria. Ratings on each criterion were recorded in a numerical scale from 0 (Not Observed) to 4 (Trait Mastered). Some criteria could appropriately be rated as "not appropriate" (NA). The total points earned were then divided by the total possible points (not including criteria marked NA) and expressed as a percentage. This percentage became the "Implementation Fidelity" as was reflective of how close the lesson came to demonstrating the CT content and skills that were targeted in the program training. The chart below indicates the total ratings (in percentage groupings) of teachers before and after the iSTEM-CT project. This comparison of the initial with final observations shows an impressive gain by teacher participants on the final RTOP administration.



On the RTOP forms, observers were also asked to comment on the overall quality of the lesson. Generally, these observations included comments on the classroom atmosphere, quality of classroom discipline and instructional proficiency. Selected observer comments will be presented later in this section. The external evaluator judged each teacher (represented only by a code number) based on these written observations as to the apparent adequacy of instruction and/or classroom management. As can be seen by the graph below, most teachers demonstrated one or more significant teaching problems on the initial observations. After the iSTEM-CS experiences, however, most teachers were rated as adequate or better.

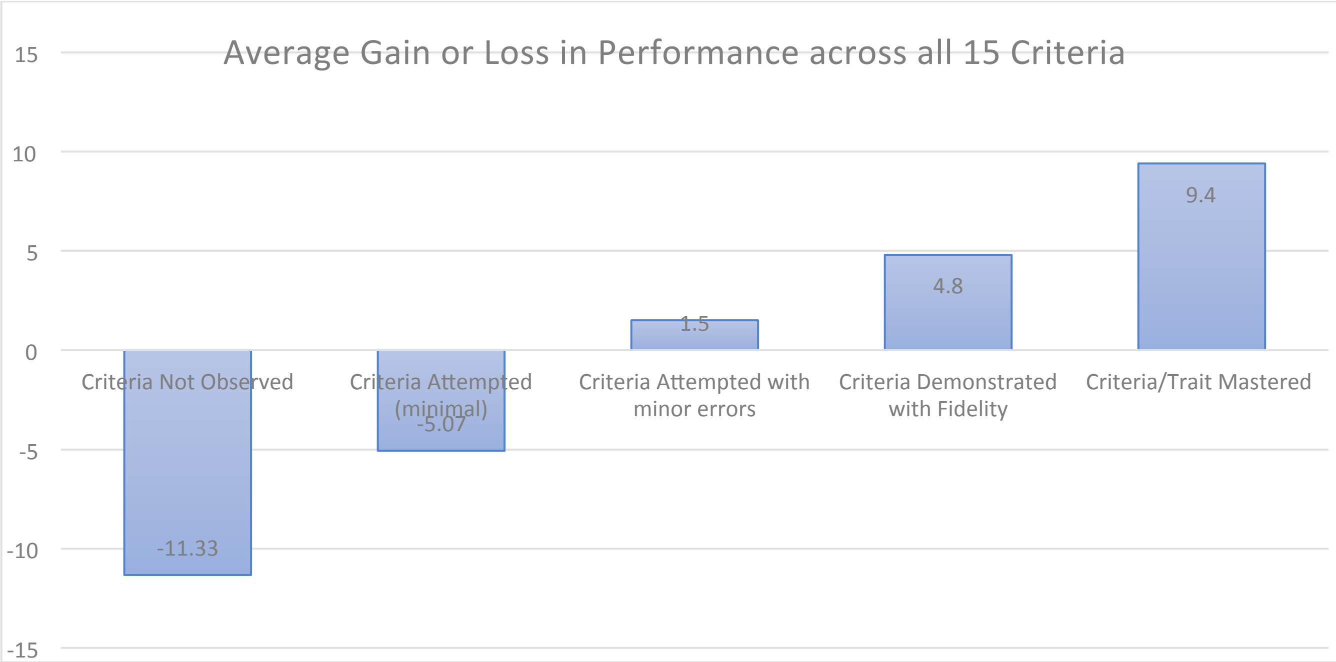



The table below shows the initial and final teacher ratings on all 15 RTOP criteria. To simplify analysis those who were rated as demonstrating fidelity with or mastery of the traits were compared with those for whom the trait was not observed. The pattern for all 15 criteria was remarkably similar. A large number of teachers failed to demonstrate the key traits on the initial observation but demonstrated the traits with either just minor errors or mastered them altogether by the final observation.

| Number of Teachers for each RTOP Rating -- Initial vs Final | | | | |
|---|---|---|---|---|
| Trait | Not Observed | | With Fidelity or Mastered | |
| | Initial | Final | Initial | Final |
| 1. Seek & Value Alternative Modes of Investigation. | 14 | 3 | 0 | 15 |
| 2. Students were actively engaged in CT | 14 | 0 | 3 | 16 |

| | | | | |
|---|---|---|---|---|
| 3. Teacher knowledge of CT triggered divergent thinking. | 17 | 3 | 3 | 16 |
| 4. A high proportion of student talk around CT. | 18 | 2 | 1 | 16 |
| 5. Students made and tested predictions, estimations and/or hypotheses. | 10 | 2 | 1 | 15 |
| 6. Students used CT strategy(ies) to represent phenomena. | 19 | 2 | 1 | 13 |
| 7. Connections with other content disciplines and/or real -world phenomena were explored and valued. | 11 | 3 | 1 | 13 |
| 8. The CT strateyg(ies) were used appropriately. | 13 | 0 | 1 | 20 |
| 9. The lesson involved fundamental concepts of the CT. | 12 | 0 | 2 | 18 |
| 10. The lesson promoted strongly coherent conceptual understanding of CT. | 16 | 2 | 2 | 15 |
| 11. The teacher had a solid grasp of CT content inherent in the lesson. | 16 | 0 | 0 | 16 |
| 12. Elements of pattern recognition were encouraged when it was important to do so (if planned for the lesson). | 6 | 0 | 0 | 14 |
| 13. Elements of decomposition were encouraged when it was important to do so (if planned for the lesson). | 7 | 0 | 3 | 18 |
| 14. Elements of algebraic thinking were encouraged when it was important to do so (if planned for the lesson). | 5 | 0 | 4 | 16 |
| 15. Elements of abstraction were encouraged when it was important to do so (if planned for the lesson). | 9 | 0 | 2 | 16 |

To view the data a different way, average gain or loss in the number of teachers who were rated in each category (Not observed – Criteria/Trait Mastered) between the initial rating and the final rating on the 15 criteria. The higher the gain, the more teachers demonstrated proficiency for a given trait. Negative numbers in the "Criteria Not Observed" and "Criteria Attempted" indicate that fewer teachers were rated in these categories on the final observation than on the initial observation. Likewise, the gain in "Criteria Demonstrated with Fidelity" and "Criteria/Trait Mastered" shows a marked improvement for all teachers on the final observation.


Average Gain or Loss in Performance across all 15 Criteria
15
10
5
0
-5
-10
-15
-11.33
-5.07
1.5
4.8
9.4
Criteria Not Observed
Criteria Attempted (minimal)
Criteria Attempted with minor errors
Criteria Demonstrated with Fidelity
Criteria/Trait Mastered

## Selected Evaluator Comments from Final RTOP Observation

The following comments were made by the $S^2$TEM Centers observers upon completion of the final observation. Note the variety of positive outcomes related to both the CT concepts and processes and overall teaching quality.

> This lesson really has it all! The students worked collaboratively in pairs to complete a digital breakout. The students needed to be able to use all the elements of CT to progress through the Deck Toy path and find the code to break out. The students' conversations were rich with CT language as they talked through the problems looking for patterns, decomposing problems to make them easier to understand, and following the steps of the Deck Toy to get to the end of the path. I have seen incredible growth on the part of Mrs. … over the course of her time in the iSTEM-CT program. She started out very reluctant and not having confidence to stretch the children's use of the CT corner stones to embracing any and every opportunity to use the elements of CT to enhance her students' learning.
>
> Ms.… is a second-year teacher who now, with one year of teaching under her belt, she has become quite a skilled facilitator. Using the knowledge learned through iSTEM CS, … has embraced the pillars of Computational Thinking and is very encouraging of her students collaborating with each other.
>
> … the teacher was much more willing to allow students to fail than previously and it was obvious that this was an expected outcome on a first trial. All students were engaged in the content even though not all were successful – but the math practice of perseverance and persistence were observed in multiple groups.
>
> Over the course of her time in the iSTEM-CS program, I have seen Mrs. … be more purposeful with her use of the CT strategies. She is intentional about what strategies to use when teaching different aspects of her content. Mrs. … has gone from a more "traditional" style of teacher talking the majority of the time to a facilitator style of teaching where her students talk more and explore through the content!
>
> When I first observed her, she was willing to use the strategies of the [CT] program, but not confident. I have seen that confidence grow over the past 2 school years with her integration of more CT strategies in her classroom as well as a more purposeful approach to using CT strategies!
>
> Overall instructional delivery has improved the past year. The teacher utilizes resources and practices that were demonstrated in the iSTEM-CS training, such as

flow charts and break-outs. These strategies have strengthened her instructional plans and consequently, student learning/ engagement.

DOK [Depth of Knowledge – an indicator of how far learning has gone beyond simple memory] has strengthened with the application of iSTEM-CS strategies integrated during instruction. Classroom management has improved with the implementation of iSTEM-CS new learning strategies (i.e., break-out rooms, additional IT resources, other CS strategies). Student engagement has increased, and the off-task time has significantly reduced.

While engaged in this highly interactive "game" students were quite reflective on their successes as well as "failures" – both generating ideas of what to do next to increase efficiency and effectiveness. The unique way of teaching Surface Area was a huge success and an experience I expect students to remember for a long time. It has been a joy to watch Debbie grow as an educator and embrace the pillars of Computational Thinking within her class.

Teacher has moved students into groups of 4-6 students by arranging desks into 2x2 or 2x3 arrays. This allows students to think, share, partner or group for math discourse. The teacher plans opportunities for discourse. While they are novices, the students do support each other in the application phase, especially when using a new IT program. Their math talk is slowly evolving from procedural to sharing/ debating ideas. Before, there was none, yet now there are sparks of discourse.

## Student Survey

The fourth and final assessment device for iSTEM-CS are the Student Surveys. These instruments were administered to 2,114 students with part of the population assessed early in the program and the other at the end of the program. It is important to note that the two groups of students are comprised of different students. This is NOT the typical pretest/posttest type of design in which the same subjects are assessed twice – before and after treatment. Since students were more or less assigned to their classes randomly by the school administration, there is no way to tell how different or similar these groups are. The chart below shows the basic demographics of the students surveyed in this project as recorded by Survey Monkey.

**CS Student Survey - Demographics**

| | Initial | | Final | | Total |
|---|---|---|---|---|---|
| | N | % | N | % | N |
| Total Students | 1360 | | 754 | | 2114 |
| Survey Completion Rate | | 100 | | 97 | |
| Classes Surveyed | | | | | |
| Mathematics | 695 | 51.2 | 637 | 84.4 | 1332 |
| Science | 468 | 34.4 | 110 | 14.6 | 578 |
| ELA | 98 | 7.2 | 5 | 0.7 | 103 |
| Social Studies | 80 | 5.9 | - | - | 80 |
| Computer Science | 18 | 1.3 | 3 | 0.4 | 21 |
| Students by Grades | | | | | |
| 6th | 366 | 26.9 | 192 | 25.5 | 558 |
| 7th | 827 | 60.9 | 486 | 64.5 | 1313 |
| 8th | 166 | 12.2 | 76 | 10.1 | 242 |
| Ethnicity | | | | | |
| White | 637 | 46.9 | 416 | 55.2 | 1053 |
| African American | 363 | 26.7 | 25.2 | 190 | 388.2 |
| Hispanic | 206 | 15.2 | 12.9 | 97 | 218.9 |
| Other | 153 | 11.3 | 51 | 6.7 | 204 |

Before examining the data from the student surveys, it will be important emphasize four caveats:

1. the students who completed the first survey were NOT the same students that completed the second survey.

2. Since different populations are represented, evaluators cannot determine what the end of course interest was for the students who completed the first survey (what changes took place in this group), nor can we determine the initial level of interest of the students who completed the second survey.
3. Thus, our operating hypothesis is that as a result of the iSTEM-CS program, a higher percentage of the students in the final assessment will show interest in the various CT categories.
4. For the purposes of our analysis, it is assumed that the reason for any difference between the first and second assessments to be significant it must be 5% or better. A difference smaller than that could be attributable to individual differences or uncontrolled experimental variations.

**Student Survey Part I -- Student Interest**

Students were asked to rate a variety of intellectual fields or careers from "very interested" to "very disinterested." Six areas of interest were most compatible with or reflective of CT knowledge and skills.

| | |
|---|---|
| Computer Programming | Mechanics |
| Electronics | Engineering |
| Science | Mathematics |

After reviewing the data, the following conclusions can be drawn regarding changes in student interest when comparing the initial and final student survey assessments of the program:

1. Overall, there were no significant (5% difference of better) when comparing the initial and final surveys.
2. When comparing the level of interest between males and females, four significant changes were evident. Females decreased in interest in both computer programming (7.45%) and electronics (8.35%). Males increased in interest in engineering (5.8%) and decreases in interest in mathematics (5.98%).
3. When comparing interest changes by grade, the data indicate that eighth grade students became more interested in mechanics (6.83%) and Engineering (22.78%). No significant changes occurred in the 6$^{th}$ or 7$^{th}$ grades.
4. No pattern of changes was detected for students when grouped by ethnicity.

Student Survey Part II – CT Related Activities

The same two groups of students (initial group and final group) were asked to indicate how often they participated in a variety of activities. Their responses could range from daily use through occasional use to no use at all. For the purpose of this evaluation, focus was placed on the four areas that most reflected interest in and activities related to CT:

Console Gaming (Xbox, Play Station, Wii, etc.)
Coding (Minecraft, scratch, etc.)
Tinkering (with CT related materials and/or programs)
Robotics

In comparing the areas above, analysis focused on whether or not there was a significant improvement in the daily and weekly (taken together) activities between the initial and final groups of students. Following the same cautions and parameters given for student interest when comparing initial with final evaluation, the following conclusions are supported by the data:

1. In comparison all students taken together, no difference in activity between the initial and final groups.
2. No significant improvement differences could be detected between males and females.
3. Two areas of improvement were present when the three grades ($6^{th}$, $7^{th}$, and $8^{th}$) were compared in the area of robotics. Sixth graders and eighth graders both improved their level of performance to a modest extent ($6^{th}$ grade = 7.55%; $8^{th}$ grade = 5.13%).
4. Limited but significant improvement was also detected when looking at students grouped by ethnicity.

| | |
|---|---|
| Console Gaming (Xbox, Play Station, Wii, etc.) | |
| Hispanic | 9.73% |
| African American | 7.99% |
| Coding (Minecraft, scratch, etc.) | |
| White | 5.55% |
| Hispanic | 6.98% |
| African American | 8.20% |

Using the teacher and student data, it is safe to conclude while there were demonstrable improvements in teacher knowledge and practices shown by teacher surveys and RTOP data. Unfortunately, those changes are not yet strongly evident in improvements in student interests and activities. We do not know at this point whether or not the improved teacher performance was able to manifest itself in student classroom performance. We suspect, but have no evidence at this time, to support the contention that more students achieved better in the classrooms of the iSTEM-CS trained teachers. Other evidence would have been helpful. Were students with iSTEM-CS teachers more engaged in their CT related classes? Did they earn higher grades in CT related classes? Did eighth graders elect to take optional high school experiences that utilized CT skills?

## Conclusions and Evaluator's Comments.

Any adult who has spent significant time in a K-12 school realizes that a contemporary school (regardless of level of financing) is an incredibly busy and stressful place (stressful hopefully limited to just faculty and staff). Schedules, local culture demands, school safety, student discipline, and staffing are some of the issues that face administrators and staff 24/7. Research and experimentation within such a context are almost always far more challenging than the pure science experimentation that one commonly associates the "scientific method." An investigator in a real school setting must accept that many of the variables he/she would like to control are beyond his/her ability to do so. Teachers who are the key element in many investigations, for example, get sick, can be relocated to other schools, take maternity leave, or switch grades within a single school. These issues notwithstanding, the iSTEM-CS project did a remarkable job in conducting a credible, useful and promising investigation.

Readers of this report should keep in mind that the Boeing-funded, iSTEM CS grant was always envisioned as a "pilot project." It was a bold experiment focused on helping more children from underserved areas to broaden their horizons by increasing their knowledge of and facility with computational thinking skills.

The importance of strong CT skills for ALL South Carolina citizens has been well established. These skills are needed for both careers and successful everyday functioning in the modern world. Students from all SC communities, not just the most affluent ones, deserve to be provided with experiences that allow them to develop these vital skills which will allow them to thrive in the broad contemporary culture.

The assessment approach for this project was appropriate and thorough. Challenging enough by itself, the assessment process for this project had the additional challenge of losing the original external evaluator early in the process. In spite of this unfortunate event, the $S^2$TEM Centers staff did a remarkable job of conducting a consistent, reliable and credible assessment while at the same time preparing a new external evaluator.

After a cursory overview of the materials from and approaches used in training teachers for iSTEM-CS, it is evident that the training protocol, techniques, and schedule all reflect cutting edge best practices for professional development. No doubt as a result of the excellent training given the participating teachers, there was a demonstrable difference in teaching knowledge, attitudes and practice as reported by teacher and observer).

As a pilot project, one of the implied goals was that the $S^2$TEM Centers staff can use information contained here and from a staff reflection process to build upon for future efforts. As an example, note the comments below provided by one of the evaluators upon completion of final RTOP rating:

> If we were able to continue working with these teachers, a logical next step would be to concentrate more closely on increasing the DOK [Depth of Knowledge] of the tasks. The tasks teachers planned were often very basic and were enhanced by the strategies and incorporation of the CT pillars. It would be interesting to ramp up the complexity of the tasks while maintaining the changes that resulted from the iSTEM CS foci. Also, more intentional planning across content areas would be great. One very large take away for me is this: How aware are students of how the CT pillars and the active learning strategies stretch across content areas? How might increased awareness better support them as learners?

A minor suggestion: in this investigation teacher content knowledge was assessed using a single matching format item on the Teacher Survey. Future use of a similar assessment item should be restructured better confirm to established rules for constructing matching items. This would add to the reliability and validity of the data generated by the item.

A special word on the unique challenges confronted by this pilot project. Deliberately choosing to work with underserved students meant that not only did the $S^2$TEM Centers staff have to improve CT learning and in doing so they had a more challenging environment in which to work. Adapting education appropriately for children of poverty is an area of intense national concern and professional exploration. The Francis Marion University Center of Excellence to Prepare Teachers of Poverty is a South Carolina resource for continued improvement in this area. Poverty may have more influence over some of the results of the Student Survey than originally imagined. Do children of poverty, for example, have access to a level of technology that could make home-based computer hobbies (computer games, etc.) a possibility? What technological support structures outside of school are available to children of poverty? Future experimentation may want to look more carefully into these issues.

Any review of the professional and/or popular literature will reveal the challenges presented by making STEM career opportunities equally available to all students. The heart of these challenges often lies in local cultures that can encourage or discourage such pursuits. While this project was not able to demonstrate any major changes in the typical patterns, this evaluator believes that it is going in an appropriate direction. New teaching skills take many years for a teacher to perfect. Research shows that it takes 5-6 years for a teacher to progress from a novice to an expert. This program was an important first step. With increased pedagogical mastery, more students should be able to achieve higher levels in CT.