Integrating Computer Science and Computational Thinking into Elementary Science

Appendix

Case Study Instruments

In each of our four case study schools, we used a variety of data collection methods, including Maker Partnership Program (MPP) teacher and principal interviews, observations of the MPP teachers’ afterschool and in-school classes, and debrief interviews following the observation. We interviewed case study teachers and principals up to twice a year, focusing on how the Maker Partnership curriculum units had been integrated into instruction, how the teachers’ practices had changed as a result of the PD and support, how the curriculum fit within the larger academic priorities of the school, and the challenges and supports associated with program implementation. The interviews also probed for the components of the PD and support that were most beneficial to implementation, and areas in need of improvement. Finally, the interviews gathered teachers’ observations on the impact of the curriculum and approach on students.

We conducted observations in the case study teachers’ afterschool programs and classrooms, focusing on documenting the instructional practices and strategies teachers employed. This included documenting how CS and CT was integrated into science instruction, how maker pedagogy was used, and how the experiences seemed to influence students’ engagement as well as their conceptual understanding and development of science, CS, and CT skills. We conducted observations of remote instruction when schools were closed due to the pandemic.

Case Study Teacher Interview Protocol (Year 2)

We’ll begin with a few overview questions.

1. What are your goals for the MPP program this year?
2. Tell me a bit about your approach to integrating computer science and computational thinking into your classroom/s. What is your overall approach?
3. How is it going so far?
4. What has gone well so far? What have been some of your successes so far this year?
5. What are some of the challenges you’ve encountered this year in terms of integrating computer science and computational thinking into your classroom? (Probe for teacher knowledge of content and pedagogy, lack of materials, student interest, lack of time to prepare, start date of makerspace, support from administration, problems with internet access or access to computers, etc.)?
6. To what degree are you using maker pedagogy to support your integration of science, computational thinking, and computer science? What does maker pedagogy look like in your classroom?
7. Are there ways that you modified challenges or lessons to differentiate for various students’ needs, abilities, and interests? (Probe for examples.)
We’ll continue with a few more questions about how the MPP program is going so far this year.

8. Tell me about the last time that you integrated CS/CT into your science instruction?
   a. What were the science, CT, and CS objectives?
   b. What was the unit that the lesson was within?
   c. What activities did students do to achieve the objectives?
   d. To what degree did you incorporate maker pedagogy into your instruction?
   e. What challenges did you encounter with this lesson/integration point?
   f. How, if at all, did you assess student learning?
   g. How did you think it went overall?

9. Have you incorporated any of the challenges that you used in your afterschool program into your classroom instruction? Which ones? How did it go?

10. Are there any additional challenges that you have faced with respect to integrating CS/CT into science? Are these challenging recurring? What additional supports (e.g., PD, coaching, materials) would help you overcome these challenges?

11. To what degree have you utilized maker pedagogy in your classroom? How would you assess maker pedagogy’s effectiveness in terms of facilitating student learning of CS/CT?

12. How, if at all, do you collaborate with the other MPP fellows at your school?

13. How, if at all, has your school administration supported your efforts to integrate CS/CT into science?

14. Have you worked with other teachers at your school who were interested in incorporating CS, CT, or maker pedagogy into their classrooms?

15. How, if at all, do you think your participation in the MPP is going to shape initiatives toward CS, CT, and/or maker pedagogy at your school?

Next, we would like to ask some questions about student assessment.

16. What CS and CT skills have your students have learned so far this year?

17. How do you assess student learning of CS, CT, and science during each lesson? (Probe for teacher-made assessments, assessments provided by MPP, informal assessment strategies, etc.) Are the assessment strategies that you have used effective?

18. What was the last assessment that you used to determine your students’ proficiency for CS/CT objectives? How effective was this assessment?

19. Are there challenges that you’ve faced in terms of assessing your students’ CS and CT skills/knowledge?

20. What additional supports would be helpful for you in terms of assessing your students CS/CT knowledge and skills?

21. Have you used the MPP badging system at all this year? Does the badging system allow for assessment of student CS/CT skills and knowledge?
We’ll continue with some questions about student outcomes.

22. How would you describe student engagement with the CS/CT integration activities that you’ve done this year? (Probe for specific anecdotes and examples.) Do you notice any differences in student engagement this year relative to other years when you haven’t been integrating CS/CT into science?

23. Are all students equally engaged in the Maker activities [probe for gender, race/ethnicity, ability level, prior CS experience differences]? Have you noticed any differences in interest or engagement levels from different students?

24. How, if at all, has student engagement in the activities changed over the course of the year? How has their understanding of computer science changed? How has their understanding of computational thinking changed? How has the way they work together to solve problems changed?

25. How, if at all, have MPP activities influenced students’ ability to collaborate? Provide feedback to their peers? Ability to problem solve?

26. How, if at all, have these activities influenced student persistence? Ability to take risks?

27. Are there any other student outcomes that you have noticed that you would attribute to student participation in Maker Partnership Program activities?

Next, I’d like to ask some questions about MPP supports.

28. What are your overall impressions of the trainings that you have participated in thus far? What aspects of the training have been most useful to you?

29. Are there aspects of the training that have not worked well for you? (Probe for: hands-on learning of Scratch, collaboration with other fellows, length of trainings, etc.) If so, what would you change?

30. How, if at all, have the trainings influenced your practice as an educator? (Probe for changes to instruction and curriculum.) Please provide a specific example of how you have adjusted your teaching as a result of something you have learned through MPP.

31. The Maker Partnership provides a number of supports to teacher fellows including on-site coaching, technical support phone calls, face-to-face professional development, and the STEMCoLab. Which of these supports do you find the most useful?

32. Are there aspects of any of these types of supports that you do not find useful or that you would change? Please explain.

33. Are there supports that the Maker Partnership does not provide that would be helpful for you?

Thank you. Before we close the interview, I wanted to ask:

34. Is there anything else that you’d like to share about the Maker Partnership that we haven’t already discussed?

35. [Turn off the tape recorder] Is there anything else that you want to say with the tape recorder turned off?
Principal Interview Protocol (Year 2)

[If principal is new to the school...] We’ll begin with a few background questions about you and your experience with computational thinking and computer science.

1. How long have you been at this school, and what is your involvement in the Maker Partnership Program?
2. Prior to participating in the Maker Partnership Program this year, what was your background in computer science and computational thinking?
3. Prior to participating in the Maker Partnership Program this year, did you have any experience with maker spaces and/or maker pedagogy? Please explain.
4. What role have you had in implementing this program so far?

[If principal is the same as the previous year, begin here.] Great. We’ll continue with some questions about the Maker Partnership Program.

5. What are your overall impressions of the Maker Partnership Program so far? What is the value-add of the Maker Partnership Program to your school?
6. How, if at all, does the Maker Partnership Program fit with other computer science- or computational thinking-related initiatives that are taking place at your school?
7. What has gone well with the program so far this year? What have been the key successes?
8. Do you see any differences in student engagement or outcomes in science classes that are integrating computer science and/or computational thinking relative to those that aren’t?
9. What challenges has your school encountered in the implementation of the Maker Partnership Program this year? (Probe for: teacher knowledge of content and pedagogy, student interest, access to technological resources, makerspace start date, etc.)
10. As an administrator, what has been your role in the MPP program? How similar/different is this this from your role last year?
11. How has Maker Partnership supported your implementation of the program within your school? How effective has their support been?
12. How, if at all, did your school plan for the transition of this program from an afterschool setting to a classroom setting?
13. Did you encounter any challenges with this transition?
14. How, if at all, do you plan to bring the practices and content from MPP to a larger number of teachers and grades at your school?
15. Do you have any plans for continuing to integrate computer science and computational thinking into science or other content areas after the Maker Partnership Program has concluded? If not, why not?
16. What supports would you need in order to scale up the MPP program at your school?

Thank you. Before we close the interview, I wanted to ask:

17. Is there anything else that you’d like to share about the Maker Partnership that we haven’t already discussed?
18. [Turn off the tape recorder] Is there anything else that you want to say with the tape recorder turned off?
## Maker Partnership Classroom Observation Tool

<table>
<thead>
<tr>
<th>Site:</th>
<th>Observer:</th>
<th>Date:</th>
<th>Start Time:</th>
<th>End Time:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Room # __________ Type of room (circle): Classroom / Science classroom / Computer lab / Makerspace / Other (describe):

Activity Summary:

Amplify Unit: _____________________________
(If not Amplify, name of Unit: _____________________________)

Relevant Amplify lesson (if applicable): _____________________________
(If not Amplify, name of lesson: _____________________________)

If activity is NOT part of an existing lesson, where does it fit in the unit?
AFTER ______________________ & BEFORE ______________________

<table>
<thead>
<tr>
<th>Student Characteristics</th>
<th>Materials Used (Check each that apply and describe):</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Students Present:</td>
<td>Book(s)</td>
</tr>
<tr>
<td># Boys: _______</td>
<td>Handouts</td>
</tr>
<tr>
<td># Girls: _______</td>
<td>Computers</td>
</tr>
<tr>
<td></td>
<td>Tablets</td>
</tr>
<tr>
<td></td>
<td>Smart boards</td>
</tr>
<tr>
<td></td>
<td>Craft materials</td>
</tr>
<tr>
<td></td>
<td>Student badges</td>
</tr>
<tr>
<td></td>
<td>Design cycle poster</td>
</tr>
<tr>
<td></td>
<td>Videos</td>
</tr>
<tr>
<td></td>
<td>Other (describe)</td>
</tr>
<tr>
<td></td>
<td>Rubrics</td>
</tr>
<tr>
<td></td>
<td>Scratch blocks</td>
</tr>
<tr>
<td></td>
<td>Post-its (for peer feedback)</td>
</tr>
</tbody>
</table>

Any adults supporting teacher & role in classroom:

___ Another MPP teacher: _____________________________
___ Another staff member: _____________________________
___ Another non-MPP teacher: _____________________________

Space Description:

Brief Summary of Observation:
Planning and Organization

How planned and organized was the session that you observed? Did students have the materials and supplies required for the activities they were doing? Did the teachers appear to be familiar with the challenge that students were working on? Were the instructions clear and did students understand what they were supposed to be doing?

Student Engagement

Please rate the level of student engagement as high, medium, or low and then provide evidence for your rating below.

<table>
<thead>
<tr>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Your Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most students do not appear interested and/or on-task during most of the activity.</td>
<td>Some of the students appear to be interested and/or on-task during periods of time but at other times, some of the students are uninterested/off-task.</td>
<td>Most or all of the students are consistently interested, on-task, and involved throughout the activity.</td>
<td></td>
</tr>
</tbody>
</table>

Explain the rationale for your rating and describe what student engagement looked like during this lesson.

Science Content and Computational Thinking

What science content, if any, is the focus or part of the lesson?

How do students engage with the science content in the activity?

Please check all of the computational thinking practices that are present in the lesson you observed and describe how students engaged in these types of computational thinking.

<table>
<thead>
<tr>
<th>Check if Observed</th>
<th>Computational Thinking Practices</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Abstraction, Decomposition, and/or Recognizing Patterns (students take a big idea/phenomenon and break it down into smaller parts for the purpose of modeling; students pull out essential elements of a problem to build a representative model; students identify similarities or differences among groups of things)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modeling and Simulation (students create a model to represent a process, system or natural phenomenon; students design a simulation to test, analyze, and/or evaluate a model)</td>
<td></td>
</tr>
</tbody>
</table>
### Check if Observed
<table>
<thead>
<tr>
<th>Computational Thinking Practices</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algorithms and Programming (e.g., write and/or debug algorithms; use or create step-by-step instructions)</td>
<td></td>
</tr>
<tr>
<td>Iteration (e.g., students use an iterative design process to create an artifact or solve a problem)</td>
<td></td>
</tr>
<tr>
<td>Decomposition (e.g., solving problems by breaking them into smaller, simpler versions of themselves)</td>
<td></td>
</tr>
<tr>
<td>Play-testing (e.g., students trying each other’s prototypes and providing feedback)</td>
<td></td>
</tr>
<tr>
<td>Data use (e.g., students create, modify, and/or manipulate data)</td>
<td></td>
</tr>
</tbody>
</table>

### Maker Learning

**Key Aspects of Maker Culture. Is there evidence of the following:**

- Did students take interest in the aesthetics and design of their prototypes?  
  - Yes/No

  **Did teachers** use the language of maker learning (e.g., referring to students as engineers or makers, referring to phases of the Design Cycle, talking about prototypes, collaborating, taking risks, improving on design/iterating, persisting through challenges, learning from failure)?  
  - Yes/No

  **Did students** use the language of maker learning (e.g., referring to themselves or each other as engineers or makers, referring to phases of the Design Cycle, talking about prototypes, collaborating, taking risks, improving on design, persisting through challenges, learning from failure)?  
  - Yes/No

- Were students given the opportunity to engage in hands-on learning?  
  - Yes/No

  Please describe opportunities for hands-on learning:

- Was the Design Cycle posted in the classroom?  
  - Yes/No

- Is the Design Cycle display interactive? (Are students and teachers moving magnets or something comparable to indicate where they are on the design cycle for their current challenge?)  
  - Yes/No

- Do the students or teacher refer to the Design Cycle?  
  - Yes/No

Please describe how the Design Cycle was used or referred to in the activity (if at all).

Did you observe any other aspects of maker pedagogy (e.g., circle meeting, circle debrief, use of challenge rubrics)? Please describe.
**Student Collaboration and Facilitation Techniques**

Please rate the level of student collaboration as high, medium, or low and then provide evidence for your rating below.

<table>
<thead>
<tr>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Your Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>There was little or no collaboration between students.</td>
<td>Students collaborated in pairs or small groups for some of the time.</td>
<td>Students collaborated in pairs or small groups for most of the time (more than half the time).</td>
<td></td>
</tr>
</tbody>
</table>

Explain the rationale for your rating and describe what student collaboration looked like during this lesson (e.g., students brainstormed design ideas together, helped each other problem solve, each had a distinct role to play in an activity, such as note-taker, programmer, tester, etc.).

Please rate the level of peer feedback as high, medium, or low and then provide evidence for your rating below.

<table>
<thead>
<tr>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Your Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are little or no opportunities for students to provide feedback to one another.</td>
<td>There was at least one opportunity for students to provide feedback to one another.</td>
<td>Students provide feedback to one another consistently throughout the lesson and demonstrated that they know how to provide specific feedback and ask helpful questions.</td>
<td></td>
</tr>
</tbody>
</table>

Explain the rationale for your rating.

Describe what peer feedback looked like during this lesson. Was peer feedback kind and supportive? Would you describe peer feedback as specific? Helpful? Did the teacher model how to give peer feedback or facilitate a process for students to give feedback to one another? In your notes, be as specific as you can, writing down language used by students when they provide feedback to their peers.
Please check all of the collaboration and pedagogical/facilitation techniques that were present in the lesson you observed and describe what they looked like.

<table>
<thead>
<tr>
<th>Check if Observed</th>
<th>Collaboration and Pedagogical/Facilitation Technique</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TAG (Tell something about the project you liked; Ask a question about something you didn't get; Give a suggestion to make the project better)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Think-Pair-Share method, in which students are given time to think on their own and then share their thoughts with a partner before being asked to contribute to a whole group discussion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Questioning strategies to promote higher-order thinking: Does teacher ask questions such as: How is this connected to…? What can you infer from…? What would happen if…? What changes would you make…?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modeling conversation: Does the teacher model ways for students to speak to one another and provide feedback to one another by using &quot;language or persuasion words&quot; (e.g., I agree that…, In my opinion…, etc.) or &quot;signal words&quot; (e.g. First of all…, In addition…, Finally…, etc.)?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Re-direction: Using techniques to re-direct students to the task at hand when they are frustrated or engaged in conflict with a student (This might be through pointing out a positive aspect of student’s work or giving students a way to clear their mind and refocus.)</td>
<td></td>
</tr>
</tbody>
</table>

Open-Ended Notes: Please use this section to describe what you observed. Note the time, in ten-minute increments. Observation notes should be descriptive and low inference, describing what you saw and heard. There is space at the end to write additional comments or questions you have based on the observation.

<table>
<thead>
<tr>
<th>Time</th>
<th>Description of Teacher and Student Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments/ Questions:
Observation Debrief/Teacher Interview

[Acknowledge any major events that took place before starting, e.g., management issues, fire drills, etc.]

1. How do you think the lesson/activity went?
2. What was most successful about this lesson?
3. What challenges did you encounter during the lesson?
4. Are these challenges recurring? Have you developed any strategies to overcome them?
5. What were your main goals for the lesson/activity? What did you want students to learn or achieve?
6. How have you/will you assess student learning?
7. How did this lesson fit in with the current unit that you are teaching? What have students already done, and where will they go from here?
8. How would you describe student engagement in this lesson/activity? Is that typical?
9. Did anything surprise you about how students engaged with this lesson/activity?
10. How did/are students moving through each step of the Design Cycle (defining a problem, prototyping, testing solutions, etc.) for this lesson/unit?
11. Did you notice any examples of students acting as makers today? (Probe for: taking risks, learning from failure, collaborating, improving on design, persisting through challenges)?
12. What changes, if any, did you make to support your students’ learning? Did you differentiate this lesson/activity for student abilities, interests, or learning styles?
13. If you did this lesson again, is there anything you would do differently?
14. How has the MPP program supported you in designing and carrying out this lesson? (Probe for professional development, webinars, on-site coaching, etc.) What supports were most helpful in implementing this lesson?

Thank you. Before we close the interview, I wanted to ask:

15. Is there anything else that you’d like to share about the Maker Partnership that we haven’t already discussed?
16. [Turn off the tape recorder] Is there anything else that you want to say with the tape recorder turned off?

Note: Gather any useful artifacts that pertain to the lesson/activity (handouts, etc.).
Teacher Surveys and Focus Groups

Through surveys and focus groups, we asked teachers to assess the quality of the PD and its influence on their confidence implementing what they learned as well as the knowledge and skills gained through the program. We also asked teachers about the extent to which they were able to implement the Maker Partnership curriculum and approaches, challenges encountered in doing so, supports received, and additional supports they would find helpful. In total, we administered six brief online surveys to teachers over the course of the project. The first survey was administered at the beginning of the first in-person PD. Subsequent surveys were administered at the end of PD sessions, including the final session held in July 2020. At the end of two PD sessions, we conducted focus group interviews in lieu of the surveys to allow the opportunity to probe teachers’ responses and gain a deeper understanding of their experiences.

Maker Partnership Program Pre-PD Teacher Survey

Prior Computer Science (CS) Experience

Please tell us about your background in computer science.

1. Have you taken any undergraduate or graduate level courses in computer science?
   - Yes
   - No
   - I don't remember

2. Have you been awarded any of the following computer science related degrees or certificates?
   - Undergraduate minor in computer science
   - Bachelors in computer science
   - Masters in computer science
   - Doctorate in computer science
   - CTE computer technology teaching certificate
   - None of the above

3. Other computer science related degrees or certificates (please specify):

4. Have you taught CS in an in-school or afterschool setting before?
   - Yes
   - No

5. If yes, please describe the courses you taught. (e.g., in-school or afterschool, grade level, CS content, etc.)

Computational Thinking (CT) Knowledge

6. How knowledgeable are you about the term "computational thinking"?
   - Not at all
   - Somewhat knowledgeable
7. What does the term “computational thinking” mean to you? (Please Specify)

8. For each of the practices listed below, please mark the box that indicates your knowledge of the practice.

- None - I have no knowledge of the practice
- Low - I know very little about the practice
- Basic - I have basic knowledge about the practice; there is more to learn
- Moderate - I consider myself somewhat knowledgeable about the practice
- High - I consider myself very knowledgeable about the practice

<table>
<thead>
<tr>
<th>Practice</th>
<th>None</th>
<th>Low</th>
<th>Basic</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Integrating computer science and computational thinking into science instruction.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>b. Making computer science relevant to students from diverse backgrounds.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>c. Assessing student mastery of computer science concepts and practices.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

Prior online professional development experience

9. How often have you participated in online learning or in an online professional learning community?

- Never
- Rarely
- Occasionally
- Frequently
- Very frequently

10. Please describe any online learning or online professional learning communities in which you've participated.
Maker Partnership Program Post PD Teacher Survey

Following is an overall list of the questions asked on post PD teacher surveys. After each PD session, we asked teachers to answer a selection of these items.

Quality of Today’s Training

Please indicate your level of agreement with the following statements (strongly disagree, disagree, agree, strongly agree):

- The goals and objectives of today’s training were clearly specified.
- Today’s training increased my computer science knowledge.
- Today’s training increased my understanding of computational thinking.
- Today’s training met my needs as a learner.
- The facilitator(s) helped me understand how to implement my learning in a science class.
- I am confident in my understanding of the Challenge lesson(s) we covered today.
- I am confident in my understanding of the computer science concepts that are related to the Challenge lesson(s) we covered today.

To what extent did today’s training increase your understanding of how to support the following in your science classroom (not at all, a small extent, a moderate extent, a large extent):

- Computer science
- Computational thinking
- Maker learning
- Playtesting
- Use of the Design Cycle

Please share any questions about today’s content that were not addressed during the training. Be as specific as you can.

What additional supports or training do you need to successfully implement what you learned in today’s training? Be as specific as you can.

Please share any challenges you anticipate in implementing what you learned in today’s training. Be as specific as you can.

What did you like the most about today’s training? Be as specific as you can.

What did you like the least about today’s training? Be as specific as you can.

What recommendations do you have for improving future trainings? Be as specific as you can.

Design and Scope of Integration

What is your role in terms of science instruction this year?

- Stand-alone teacher
- Classroom teacher who receives science push in support
- Science teacher who pushes into other classrooms
- Technology or CS teacher
1. Have you integrated computer science (CS) or computational thinking (CT) into a science lesson yet this year? Yes/No
   If yes: Please provide an example, from your most recent unit, where you integrated CS or CT into a science lesson. Indicate the science concepts you covered in the lesson.
   Did you use a maker approach in this lesson? Yes/No
   If yes: How did you use a maker approach in this lesson?

2. How many lessons have you taught where you have integrated CS or CT into science?
   - I have not integrated CS or CT into science yet.
   - 1-3 lessons
   - 4-6 lessons
   - 7-10 lessons
   - More than 10 lessons

What are the challenges you face in integrating CS/CT into science lessons?

How many times have you formally assessed your students’ CS and/or CT knowledge this year?
   - 1 time
   - 2 times
   - 3 times
   - Four or more times

What tools have you used to assess your students’ CS/CT skills and knowledge?
   - MPP rubric
   - MPP assessment
   - Self-made rubric
   - Self-made Scratch assessment
   - Other (please describe):_____________________________________

What does the term “maker pedagogy” mean to you now? Be as specific as you can.

How many times have you collaborated with the other MPP Fellow at your school (please skip this question if you are the only MPP teacher at your school):
   - Never
   - 1-3 times
   - 4-6 times
   - 7-10 times
   - More than 10 times

To what extent have you been able to implement what you have learned through the MPP?
   - A small extent
   - A moderate extent
   - A large extent
To what extent have you modified what you have learned through the MPP for your students?

- A small extent
- A moderate extent
- A large extent
- Not at all

If applicable, please describe how you have modified the curriculum.

To what extent have the following individuals supported your ability to integrate CS/CT into your science classroom (a large extent, a moderate extent, a small extent, not at all)?

- The other MPP teachers at my school
- Other teachers in my school who are not MPP teachers
- Colleagues at other schools I have met through MPP
- Administrators in my school
- School or network technology coordinators
- Staff from Schools That Can or MakerState

In lessons where you have integrated CS/CT into science, how frequently have you used the following elements of maker pedagogy (never, in some lessons, in most lessons, in all lessons):

- Circle meetings
- Circle debriefs
- Design Cycle poster
- Elements of Design Cycle (without the poster)
- Hands-on learning
- Peer support or collaboration
- Use of maker language (e.g., referring to students as engineers or makers, referring to Design Cycle, learning from failure, etc.)
- Use of a teacher-built prototype
- Student badging
- Student self-assessment rubrics

What does maker pedagogy look like in your classroom?

How are you using maker pedagogy to support the integration of CS/CT into your science lessons?

What challenges have you encountered with using a maker pedagogy?

What are the challenges have you encountered with using maker pedagogy while integrating CS/CT into your science lessons?

What does the term “computational thinking” mean to you now? Be as specific as you can.

To what extent have the following increased since the beginning of the Maker Partnership Program last year (not at all, a small extent, a moderate extent, a large extent)?

- My ability to critique colleagues’ contributions of best practices
● My ability to learn from colleagues’ contributions of best practices
● My understanding of computational thinking
● My understanding of Maker learning strategies
● My ability to engage students in computer science activities
● My ability to use Maker learning to facilitate an equitable learning environment
● My ability to assess students’ mastery of computer science and computational thinking

In what other ways has the Maker Partnership Program had an influence on your teaching and instruction?

Please indicate your level of agreement with the following statements (mark one for each) (strongly disagree, disagree, agree, strongly agree):

● My students find the Challenges we are completing in our makerspace to be engaging
● My students find programming/coding in our makerspace to be engaging
● My students find building their own Prototypes to be engaging
● My students are developing habits of persistence in our makerspace
● My students understand what the Design Cycle is
● My students are able to use the Design Cycle to improve their work
● My students are willing to take risks in our makerspace
● My students learn from their failures in our makerspace
● My students take ownership of their projects in our makerspace
● My students support their classmates as they work on their Maker projects

To what extent did you observe improvement in the following areas as a result of integrating CS and/or CT into your science class (not at all, a small extent, a moderate extent, a large extent)?

● Student engagement
● Problem-solving among students
● Communication and collaboration among students
● Knowledge retention
● Student confidence in coding
● Student confidence in computational thinking
● Understanding of scientific phenomena

In what other ways has the Maker Partnership Program had an impact on your students?

Maker Partnership Program Supports and Challenges

How helpful are the following Maker Partnership Program supports as you implemented the CS and CT in your science classroom (not applicable, not at all helpful, a little helpful, moderately helpful, very helpful)?

● In-person coaching
● STEMCoLab lessons and videos
● STEMCoLab Prep & Practice artifact submissions and discussions
● Check-in calls with a Maker coach
● Principal observations
- Awarding mastery badges\(^1\) to students
- Webinars
- Office hours

Is there anything that prevents you from using any of the above supports (e.g., time, access, resources)? Be as specific as you can.

In the last month, approximately how often have you logged into the STEMCoLab?
- Never
- Once or twice
- About once a week
- Two to three times per week
- Daily or almost daily

Are there any challenges or questions that you have about using the STEMCoLab? Be as specific as you can.

To what extent have the following been challenges for you as you integrated CS and CT into your science classroom: (not at all, a small extent, a moderate extent, a large extent)
- Lack of preparation time
- Lack of classroom management skills
- Limited understanding of how to implement computer science in my science classroom
- Limited understanding of how to implement the Challenges in my science classroom
- Limited understanding of how to implement Maker learning in my science classroom
- Lack of computer science knowledge
- Developing Scratch or other CS prototypes for your students to use and learn from
- Assessing students’ CS, CT, and science competencies
- Lack of knowledge about computational thinking
- Lack of knowledge of the maker learning approach
- Limited understanding of how to operate computer science software/hardware
- Lack of student interest in computer science
- Lack of administrative support
- Lack of computer hardware
- Lack of computer software
- Unreliable internet access
- Other (please describe): __________________________________________

**Logistics and Planning**

How many students are currently enrolled in your science classroom (or classroom where you integrate CS and CT into science)?

How often do you teach science?

Is there other CS training that you have participated in since starting MPP in September 2018?

How many students, on average, attend your makerspace every week?

\(^{1}\) Students earned badges for mastery of a science or CS skill or concept, as demonstrated by successfully solving a challenge and creating a prototype that embodies a science/CS concept.
How have you integrated strategies from this program into your in school science instruction, if at all? Select all that apply.

a) I have not yet thought about how to integrate strategies from this program into my in-school science instruction
b) I have given some thought to this, but have not made any definite plans
c) I have made changes to some of my lessons plans
d) I have integrated aspects of maker learning into my teaching
e) I have used CS tools and/or strategies from this program in my science lessons
f) I have integrated computational thinking strategies from this program into my science lessons
g) Other (specify) _____

Do you know what subject and grade levels you will be teaching next year? If so, please indicate the subject and grade levels you expect to teach.

Subject: ____________________
Grade levels:________________

Do you plan to award student badges for the Challenges reviewed in today’s training?

- Yes
- No
- Not sure

If yes, how do you plan to award badges? (Who determines if a badge was earned? Who awards the badge? When is the badge awarded? How are students who earned a badge recognized?)

If no, why not?

Is there anything else you would like to tell us about your experience with the Maker Partner Program?

Thank you!
Teacher Post PD Focus Group Protocol

Quality of Training and MPP Supports and Challenges

1. What was most useful for you from today’s PD? What was least useful?
2. How, if at all, did today’s PD improve your understanding of CS, CT, maker pedagogy?
3. How, if at all, did today’s training improve your understanding of how to integrate these into your science classroom?
4. What are the changes you’re going to make to your science instruction based on today’s PD?
5. What did you like most about today’s PD? What did you like least about today’s PD?
6. What recommendations do you have for improving future PDs?

Understanding How Teachers Are Integrating CS/CT Into Science Classrooms

1. How often are you integrating CS/CT into your science classrooms? How often are you doing so with the use of maker pedagogy?
2. What MPP resources or supports have you used in preparing to integrate CS/CT into your science classrooms recently? (Probe: How, if at all, have you used the STEM CoLab or feedback from MPP coach observations?)
3. Do you have examples of how you’ve used a colleague’s expertise, materials, or feedback in shaping your own instruction recently?
4. What additional supports do you need to successfully integrate CS/CT into your classroom?
5. How would you assess maker pedagogy’s effectiveness in terms of facilitating student learning of CS/CT?
6. How, if at all, are you using the Design Cycle in your classroom this year? (Probe: Are you using the Design Cycle in the same way as it was introduced to you last year? How have you adapted it?)
7. What are some challenges you’re encountering as you’re integrating CS, CT, and/or maker pedagogy into your science classrooms?

Teacher Outcomes

1. How, if at all, do you feel like you have improved your understanding of these concepts since last year?
2. What do you feel like you need to know more about in terms of your knowledge of computer science, computational thinking, and maker pedagogy?
3. Do you feel like integrating CS, CT, and/or maker pedagogy into your science classroom has made you a more effective instructor? Why do you say so?

Student Outcomes

1. How are you assessing your students CS/CT learning?
2. What evidence do you look for to demonstrate that your students are thinking computationally?
3. What is the added value of integrating CS and/or CT into science? Are your students getting something from this integration that they would miss without it?
4. How, if at all, does maker learning enhance your students’ science learning? (Probe: Do you feel that integrating CS, CT, or maker pedagogy in your science classroom enables your students to take more risks? Does it help them learn from their failures? Does it help them take more ownership of their work?)
School Outcomes

1. Do you think your school’s approach to CS or science education has changed because of your participation in this program? If so, can you give us some examples of how this is the case?

2. How, if at all, has your school’s approach to science education has changed because of your participation in this program?

3. What opportunities have you had to share what you’ve learned through MPP with your colleagues?

4. How, if at all, will you continue to integrate CS, CT, and/or maker pedagogy into your science classrooms next year? Why or why not do you think you’ll do so?
   Probe: How will you modify your integration of CS, CT, and/or maker pedagogy for your science class next year?

Closing:

Is there anything that you wanted to talk about that we haven’t discussed in our conversation?

Thank you for your time today! If you have any questions, please don’t hesitate to be in touch with us.
MPP PD Partner Interview Protocols

At the end of each implementation year, we interviewed representatives from our practice partner organizations.

Maker State/ Schools That Can Interview Protocol (YEAR 2)

Background

To begin, I’d like to ask a few questions about your organization, your role in the Maker Partnership Program, and your overall impressions of the Maker Partnership Program so far.

1. If first-time interview: What is your role and how long have you been working with [organization name]?
2. What are your primary responsibilities with respect to the Maker Partnership Program?
3. If repeat interview: How, if at all, has your role changed over the course of the last year with respect to the Maker Partnership Program?

Partnerships with Schools

Now, I’d like to ask more specifically about your work with schools participating in MPP.

1. Over the past year, what has been most successful about the various types of supports for teachers? What has worked well? During remote instruction, what school supports were the most successful? What worked well? (Probe for: How, if at all, was this different from the first year of MPP when teachers were in the afterschool setting?)
2. Over the past year, what challenges have you encountered with respect to providing supports for teachers and/or schools? How, if at all, did these vary from the in-class setting to remote instruction?
3. What strategies did you used to overcome these challenges?
4. What, if any, challenges have you not been able to address?
5. Looking back, is there anything you would have change about how you provided these supports to teachers and/or schools?
6. What kind of support or resources did you need more of to support teachers and schools during remote instruction (i.e., technical support, pedagogical support, other)?
7. Based upon your visits to participating classrooms (when school was in-person and remote), have you noticed a range of how schools are implementing MPP in the in-class setting? Describe the school with the strongest implementation of MPP. What do you think accounted for their success? Have you noticed a range of how schools are implementing MPP remotely?
8. Which of the schools would you say was struggling with implementation of MPP in the in-class setting the most? What was preventing this school from being successful? For remote instruction, which school was struggling the most? What was preventing this school from being successful?
9. How, if at all, did the Maker Partnership Program focus on addressing special school populations (e.g., low-income, female students, students with IEPs, disabilities, or ELLs) this year?
10. In what ways did you engage school administrators in the implementation of the MPP this year? Did they receive any supports/training regarding how to best support MPP teachers? In light of the recent transition to remote instruction, how did your engagement with school administration changed, if at all?
Questions about the Partnership Model

1. Has the RPP approach changed the way that you work with schools?
2. Has the partnership model led to any key learnings or “aha-moments” for you? Please describe.
3. What about the RPP model, in general, has worked well for you so far?
4. Have you experienced challenges associated with working in close partnership with researchers? What might you want to change for the upcoming year?

Conclusion

Before we close the interview, I wanted to ask:

5. Is there anything else you would like to add that I have not asked about (Probe for: aspects of your role, successes/challenges you have experienced)?
Student Survey

MPP Student Survey

At the beginning and end of each school year, we administered online surveys to students to assess their growth in important mediating outcomes, including attitudes and dispositions toward science, CS and CT, as well as reactions to the pedagogical approach and content taught (e.g., interest in the activities, self-assessed knowledge gained). Below includes the overall list of questions we asked across all survey administrations.

Home/Prior Exposure to Computer Programming

- Do you have a computer at home you can use? Yes/No
- Do you have a tablet at home that you can use? Yes/No
- Do you have a smart phone at home that you can use? Yes/No
- Do you have internet access at home? Yes/No
- Have you taken any computer programming classes in school or out of school (afterschool, camp, etc.)? Yes/No
- Have you ever learned a programming language (like Scratch)? Yes/No

CS Confidence

- I can make a computer program (strongly disagree, disagree, agree, strongly agree)
- Computers are difficult to use (strongly disagree, disagree, agree, strongly agree)
- Computer programming is hard for me (strongly disagree, disagree, agree, strongly agree)
- I am good at computer programming (strongly disagree, disagree, agree, strongly agree)

Science Confidence

- I am good at science (strongly disagree, disagree, agree, strongly agree)
- I get good grades in science (strongly disagree, disagree, agree, strongly agree)
- Science class is hard for me (strongly disagree, disagree, agree, strongly agree)
- I can use a computer to solve a science problem (strongly disagree, disagree, agree, strongly agree)

CS Interest

- I enjoy creating things with a computer (strongly disagree, disagree, agree, strongly agree)
- It is important for me to learn how to use a computer (strongly disagree, disagree, agree, strongly agree)
- I am curious about how computer programs make computers work (strongly disagree, disagree, agree, strongly agree)
- I enjoy making computer programs (strongly disagree, disagree, agree, strongly agree)
Science Interest

- I enjoy learning new ideas about science (strongly disagree, disagree, agree, strongly agree)
- I get excited about science (strongly disagree, disagree, agree, strongly agree)
- I enjoy doing science projects (strongly disagree, disagree, agree, strongly agree)
- I have fun learning science (strongly disagree, disagree, agree, strongly agree)

Maker Pedagogy

- I like to figure out how to make things (strongly disagree, disagree, agree, strongly agree)
- I like solving problems in teams (strongly disagree, disagree, agree, strongly agree)
- I like to take apart or build things to see how they work (strongly disagree, disagree, agree, strongly agree)
- After I make something, I like to keep improving it (strongly disagree, disagree, agree, strongly agree)
- I do not give up easily (strongly disagree, disagree, agree, strongly agree)
- I like to finish whatever I start (strongly disagree, disagree, agree, strongly agree)
- I can work well with others (strongly disagree, disagree, agree, strongly agree)
- When solving a problem, I try to hear opinions that are different from mine (strongly disagree, disagree, agree, strongly agree)
- I feel comfortable asking another student to help me when I am stuck on my work (strongly disagree, disagree, agree, strongly agree)
- I do not like when people suggest changes to my work (strongly disagree, disagree, agree, strongly agree)

Equity

- People who look like me are good at computer programming (strongly disagree, disagree, agree, strongly agree)
- There are many girls who are excellent at computer programming (strongly disagree, disagree, agree, strongly agree)
- Boys are better at computer programming than girls (strongly disagree, disagree, agree, strongly agree)
- Girls can do just as well as boys in computer programming (strongly disagree, disagree, agree, strongly agree)
- I could see myself as a computer scientist in the future (strongly disagree, disagree, agree, strongly agree)
- How good you are in computer science is something that stays pretty much the same (strongly disagree, disagree, agree, strongly agree)
- I can get better at computer science (strongly disagree, disagree, agree, strongly agree)

Reaction to Maker Pedagogy and Content Learned

- Getting badges made me excited to continue learning (strongly disagree, disagree, agree, strongly agree, did not receive badges)
- I know how to use the Design Cycle (discover, create, improve) to solve problems (strongly disagree, disagree, agree, strongly agree)
- Participating in this afterschool program made me excited about learning computer science (strongly disagree, disagree, agree, strongly agree)
- My confidence about computer science has increased since I started this afterschool program (strongly disagree, disagree, agree, strongly agree)
- What was your favorite part of this afterschool program?
- What was your least favorite part of this afterschool program?
Student Assessment

MPP CT/CS Assessment

In the second year of implementation, we administered a pre/post online assessment to measure students’ growth in CS and CT skills. The project team designed the assessment to measure students’ computational thinking skills. The assessment is based on other existing assessments including the CTA-M- (Wiebe et al., 2019), the CSCI- (Rachmatullah et al., 2020), the VELA, – (Grover et al., 2019), and the Bebras Computing Challenge, 2017), as well as new items created by MPP. For each question, we note the source of the item. The final post survey and assessment were administered at the end of the 2019-2020 school year, when all instruction was occurring remotely due to the pandemic.

Question 1
(Question 3 from CTA-M)

In what step of Julia's program is there a mistake?

A. Step A
B. Step B
C. Step C
D. Step D
**Question 2**

(Question 2 from CTA-M/Bebras)

Help the green robot to exit the maze.

The arrows below represent the instructions that the green robot can follow.

Choose the correct set of instructions that will take the green robot to the exit. The robot will repeat these instructions 4 times.
Question 3
(Based on CSCI question 8)

Read the following piece of code:

What words will be said by this sprite after the green flag is clicked?

A. “Apple Apple Apple Orange Orange Orange”
B. “Apple Orange”
C. “Apple Orange Apple Orange Apple Orange”
D. Nothing will be said
Question 4
(based on CTA-M question 17)

Note: “If path” means “If there is a path”

A. A
B. B
C. C
D. D
**Question 5**  
(from Bebras Challenge 2017)

A worm sits at the end of a branch of a big tree.

The worm wants to eat all the apples by moving through the tree branches. The tree is made of branch sections that are each 1 foot long.

What is the shortest distance that the worm has to crawl to eat all of the apples?

A. 4 feet  
B. 9 feet  
C. 13 feet  
D. 15 feet
**Question 6**  
(Created by MPP)

Alexa is trying to write a program to make the cat walk to the apple.

The red arrow points to a space where Alexa needs to add one more block to make her program work. What block should she add?
Question 7  
(from CTA-M question 20)

What step should he add to his program?

A. Option A
B. Option B
C. Option C
D. Option D

Option A: move forward
Option B: turn right
Option C: turn left
Option D: Not missing any step
Question 8
(Question 1 from VELA)

The program below sets an alarm to a specific time based on the day of the week. Use the program to answer the following questions.

What will the alarm be set to if the day is Thursday?

A. 7
B. 8
C. 9
D. 10
Question 9
(From Bebras Challenge 2017)

Below is a map of the roads in a place called Circle City. Drivers there go around a “traffic circle” when roads come together (no traffic lights there!) In Circle City, people do not give instructions like:

“At the first traffic circle, take the 1st exit. At the second traffic circle, take the 2nd exit. At the third traffic circle, take the 4th exit.”

Instead, the people give directions by using sequences of numbers, like "4 1 2" which would make a driver go this way (see the green line).

If we start from A and follow the sequence “3 1 3 2 3” where will we end up?

A. A  
B. B  
C. C  
D. D
Look at the program below and answer the following question:

What will this program make the beetle do?
Data Analysis

**Quantitative Data Analysis.** We analyzed the teacher and student surveys, and student assessment descriptively (e.g., frequencies and distributions) and longitudinally (e.g., looking at changes from pre to post surveys, from year one to year two). We tested the statistical significance of pre/post differences for students who completed both surveys. Our practice partners reviewed the face and construct validity of the scales, and provided input on the content and item wording.

**Qualitative Data Analysis.** To analyze qualitative focus group, interview, and observation data, we applied an iterative coding process in which we labeled segments of text with codes that “assign symbolic meaning to the descriptive or inferential information” compiled during the data collection process (Miles, Huberman, & Saldaña, 2014). We developed codes both deductively, drawing upon prior research, and inductively, allowing codes to organically arise from our field data. The intent of the inductive coding and analysis is to allow the data to speak for itself and illustrate categories and relationships that were not previously considered. The codes were used to conduct deductive and inductive analysis within a data matrix that allowed for within-case and across-case analysis (Miles & Huberman, 1984).

Using a mixed-methods framework, we triangulated across qualitative and quantitative data sources to capture and understand how MPP was implemented at the classroom level (both after school and during the school day), its influence on teacher practice and student learning, and how it could be improved through specific PD strategies, resources, and school-level supports. As data were collected and analyzed, we regularly reviewed findings with our practice partners and engaged in collaborative sense-making. This ensured that the research informed the development and improvement of PD and supports, and that our understanding and interpretation of the data reflected practitioner perspectives and the context within which the work was conducted.