StoryCoder Classroom Feasibility Study

Part of an Institute for Education Sciences' Small Business Innovation Research Phase I Research Grant

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WestEd is a nonpartisan, nonprofit research, development, and service agency that works with education and other communities throughout the United States and abroad to promote excellence, achieve equity, and improve learning for children, youth, and adults. WestEd has more than a dozen offices nationwide, from Massachusetts, Vermont, Georgia, and Washington, DC, to Arizona and California, with headquarters in San Francisco.

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Study Overview

In December 2018, WestEd partnered with codeSpark to conduct a classroom feasibility study on their newly developed product StoryCoder. This research and development project was funded by the Institute of Education Sciences under the Small Business Innovation Research program. The purpose of the study was to understand whether StoryCoder is an effective and manageable product for teachers and students to use in a classroom setting. StoryCoder is a game within the larger codeSpark mobile app, and it helps engage young students in early programming concepts through creating stories.

Research Questions

The research questions that guided the feasibility study were:

- Is StoryCoder feasible for elementary classroom use such that teachers are able to integrate the app into their regular curriculum?
- Are teachers able to use the companion curriculum/resources to inform instruction and planning?
- Are students able to progress through StoryCoder in the classroom?
- Is StoryCoder an effective tool for teaching basic computational thinking and programming skills?

The following report presents the findings related to each of the research questions and concludes with recommendations for further development and research of StoryCoder. This study was reviewed and approved by both WestEd's Institutional Review Board (IRB) and the research department of the district in which the study was conducted.

Study Design & Methodology

Participants

The study involved teachers and students from eight early elementary classrooms across two elementary schools in a large west coast school district. At each school there were four classroom teachers and one on-site coordinator who participated (10 total adult participants). The on-site coordinators had multi-

grade support roles at their schools with a focus on technology instruction. See Table 1 for an overview of the participating teachers.

TABLE 1

Participant Demographic Information

Participant	School Site	Grade level(s)	# of Consented Students	Gender
Teacher 1	A	K	12	F
Teacher 2	A	1st	13	F
Teacher 3	A	1st	10	F
Teacher 4	A	2nd	10	F
On-Site Coordinator A	A	K-5	n/a	M
Teacher 5	B	1st	19	F
Teacher 6	B	1st	12	F
Teacher 7	B	1st	11	F
Teacher 8	B	2nd	7	F
On-Site Coordinator B	B	K-5	n/a	M

The study also involved the students in those eight teachers' classrooms. All students participated in the study activities, but students' parents received an active consent form in order to choose whether their student's data could be used for the study. Both school sites were part of an initial group of schools piloting computer science instruction during the 2016-2017 school year; this is a significant detail in that most of the participating students had some prior experience with learning basic computer science concepts (see Table 4 for students' familiarity with coding apps). Table 2 provides demographic information about the two school sites.

TABLE 2
School Demographic Information

		School A	School B
School-Level Breakdown ('16-'17 School Year)	% Free or Reduced Lunch	83.9%	34.3%
	% English Learners	69.5%	23.5%
	Total Enrolled Students	**635**	**533**
School-Level Ethnicity Group ('16-'17 School Year)	African American	1.2%	1.1%
	American Indian or Alaska Native	0%	0%
	Asian	86.6%	45.8%
	Filipino	0.4%	2.6%
	Hispanic or Latino	4.6%	9.8%
	Pacific Islander	0.3%	1.1%
	White (Not Hispanic)	1.2%	26.1%
	Two or More Races	1.5%	7.7%

Study Intervention

Teacher participants engaged in the following activities as part of the study:

- Attended a 1.5 hour training session on the use of codeSpark and StoryCoder. The trainings took place at both school sites. codeSpark staff walked through the app and curriculum, and WestEd staff covered study logistics.
- Distributed and collected consent forms for parents/guardians.
- Supported the administration of the pre-and post-assessments.
- Used StoryCoder on three consecutive days during literacy lessons. Lessons lasted between 35-60 minutes. Teachers were provided with codeSpark-developed lesson plans and curricular materials for each day. For more information, see the section under the second research question ("Are teachers able to use the companion curriculum…").
- Allowed 1-2 researchers from the WestEd team to visit their classroom at least once to observe their use of the app.
- Attended a one-hour focus group following the class' use of StoryCoder.

Of the eight classrooms, two classrooms were separated into a control condition. These classrooms did not use StoryCoder until after taking the post-assessment.

Data Collection

To address the four research questions, the research team collected and analyzed the following sources of data:

- *Student Pre-/Post-Assessment* – Students took an assessment before and after using StoryCoder. This assessment, created specifically for this study and designed for pre-literate students, included various items focused on measuring students' abilities with sequencing (putting things in the right order so that they make sense). The assessment consisted of 11 questions, two of which were used as worked examples to help students know the mechanics of answering a set of questions. The assessment was read and administered to a class of students while students wrote answer choices on individual answer sheets.
- *Student Pre-/Post-Survey* – Taken along with the assessment, the survey asked students about their attitudes towards storytelling (4 questions), exposure to pre-literate coding apps (3 questions on the pre-survey only), and thoughts about using StoryCoder (1 question on the post-survey only). Students responded to the questions about attitudes towards storytelling and thoughts about using StoryCoder on a 5-point Likert Scale using smiley faces to represent negative to positive emotion (i.e., Don't Like to Like, or Very Bad to Very Happy).
- *Classroom Observations* – 1-2 WestEd researchers conducted at least one observation per classroom and at least one observation for each of the three lessons.
- *Student Artifacts* – A sample of students' stories were analyzed to see the tangible products of their work.
- *Teacher Post-Implementation Focus* Groups – Two 1-hour focus groups were conducted (one at each school) to gather teachers' reflections on their experience and their suggestions for possible changes to StoryCoder and the curriculum. Researchers followed a focus group protocol designed to elicit discussion on the four research questions.
- *Demographic Information* – Contextual information for the two school sites (see Table 2).

Data Analysis

Assessments and surveys from consented students were hand-scored and cleaned by researchers. The scoring rubric for the assessment had a maximum score of 23 points (see Table 5 for the maximum score for each question). A series of paired t-tests were used to analyze changes in the mean from pre- to post-assessment on student overall achievement and student achievement by experimental condition. Likert survey responses were transposed to numerical values (i.e., 1–5 for negative to positive responses) so that mean responses and changes from pre to post intervention could be reported.

Field notes from classroom observations were reviewed for themes across the classrooms and lessons, as well as for evidence that stood out as significant for understanding how StoryCoder was being used and received in the classroom. Similarly, records from the focus groups were analyzed for salient themes and

supportive quotations from the participants. Quotations from the focus groups were transcribed from audio recordings and slightly edited for readability (e.g., removing "um," "like," and tangential speech).

Student artifacts were collected by recording video of an iPad screen while a researcher clicked through all elements of a story in play mode, and then clicked through the story's commands in edit mode. These videos were analyzed using a protocol covering six themes: Sequencing, Storytelling, Genre, Language Use, Use of StoryCoder Features, and Other (anything of interest that did not fit in the above categories).

Findings

Is StoryCoder feasible for elementary classroom use such that teachers are able to integrate the app into their regular curriculum?

General teacher and student activity during implementation

More detailed information on the particular lessons will be shared below under the section on the second research question ("Are teachers able to use..."). However, there were some general trends that occurred across the three days of implementation. For instance, most students across the three classrooms seemed to readily pick up the fundamentals of the app. Teachers noted that starting on the first day, students began using the app with little hesitation. As one teacher put it, "once they see it, once they know what to do, they don't feel like they're afraid."

This low barrier to entry was helpful given that teachers were usually busy working with students one-on-one during class time. During observations, researchers regularly noted that several students' hands would be raised with questions and addressing these students' needs kept the teachers fairly busy. One positive sign was that students were also observed regularly helping each other. Students were happy to talk to each other about what they were doing and to seek help from those sitting nearby. One teacher reflected that this may have helped address disparities in skill with the app.

One aspect of student use that could be both positive and negative is students' readiness to add many characters and objects to their story. Many students were observed filling their scene with an abundance of characters and objects. This is a positive sign of the app's potential as a creative tool. On the other hand, this readiness to add many characters/objects has the potential to take focus away from thoughtful and effective storytelling. Future use of the app in classrooms should consider how to harness this momentum—but of course not stifling students' creative energies.

An example where students' excitement became a potential hindrance was in using the microphone command. Teachers reported that some students got "stuck" given how exciting this feature was, and this prevented them from more productive use with other parts of the app.

Sharing stories generated interest and engagement

Students were very happy to share their stories at the end of class. In some classrooms, all or nearly all students raised their hand to volunteer sharing their story. Some students readily went to the front of the classroom to share their story even when they did not appear to have a full story created or to be ready to explain what it was. This excitement can be leveraged in future classroom use, since StoryCoder appears to be a medium that is easy to view as a class. That said, all classrooms in the study had access to a document camera connected to a projector or large screen, and these were regularly used to share student or teacher work in the app to the classroom; however, other classrooms may not have this technology, and future iterations of the curriculum should consider how stories could be shared in a variety of classroom settings.

An alternative form of sharing that took place at one of the school sites was a gallery walk. After the post test, the teacher had students set out their iPads on the table, and students circulated around the room viewing each other's work. Students seemed to enjoy this. A downside to this format is that the order of WhenTapped events isn't clear to other viewers, and students were tapping characters in their classmates' stories somewhat haphazardly.

Alignment to teachers' current instruction and curriculum

Engagement was accessible to all learners

Teachers were happy with how StoryCoder engaged all learners in their classrooms, even with regard to students of various levels of background skills. One teacher complimented how the app provided structure for kids even if they didn't know how to write. Likewise, a teacher noticed and was pleasantly surprised by some quieter students speaking loudly into the microphone. Another teacher observed positively that she has "one autistic child who really enjoyed doing this and I watched him play around with all the keys, and he remembered things and picked them up really fast."

Has the potential to be an effective support in teaching story sequencing

Teachers were complimentary of how StoryCoder could be used to reinforce their teaching around the sequencing of stories, i.e., the structure of beginning, middle, and end. For instance, one of the teachers commented, "With kindergarten, we start with our narrative writing, and the beginning, middle, and end does help them, and [the app] gives them another way to of telling a narrative story... a more fun way of doing it." However, as it was implemented during the study, the teachers felt like they didn't have enough time to see this sequencing fully realized. This point about student progress is covered more fully in the section on the third research question ("Are students able to progress…").

Some procedural similarities to the structure of writer's workshop

A couple teachers commented on how the basic format of the app's implementation had some helpful parallels to their existing writing instruction:

> *"It is sort of like what we do during writing workshop and reading workshop: we modeled it, and then they went and did their own. It was really cute. They had the sequence down, but all of them created something a little unique and tweaked it to their own style."*

Potential Future Use

During the focus groups, many ideas arose for how the teachers would consider using StoryCoder as part of future classwork. Below are several of those ideas and suggestions.

Increased involvement of non-fiction

In the focus groups, teachers expressed a desire for StoryCoder to address non-fiction and informational writing, since this is a major point of focus in their literacy standards such as the Common Core State Standards. Teachers listed several genres of non-fiction writing that they currently use as part of their curriculum:

- "How to" books – Writing a step-by-step guide for an action, e.g., making cookies.
- "All about" books – Picking a topic and writing facts about it, possibly with some research.
- Science writing – For instance, writing about mountain lions or the water cycle.

For the third bullet above, teachers mentioned that it would be helpful if the scenes, characters, and objects could support this type of writing. For instance, if there was a water cycle "theme" from which students could easily access the necessary story elements. This suggestion has the potential to require a lot of resources to develop, so it may be prudent to explore this with future information gathering and formative testing. However, as one teacher put it, this could be StoryCoder's way of supplementing and extending the aspirational writing that takes place outside of the app.

Teachers mentioned that this non-fiction genre writing could be supported by a picture taking feature, in order to demonstrate an observation or to connect a real object to their personal storytelling. StoryCoder already has a picture taking feature that may fulfill this need, but it was not part of the teacher training or curriculum. Although the teachers didn't realize it was there, several students were observed using it during observations and the analysis of student artifacts. This feature may be a source of untapped potential for future students who are ready to take on the full suite of StoryCoder features.

Increased ability to create or include student-created media

Related to the above topic of using the picture feature, some of the teachers wanted students to have the ability to create their own elements (characters, objects, and scenes) to add into the app. Their reasoning was that the existing items may not be a good fit for the kind of story they want to tell. For instance, one

teacher said being able to draw things and add them in would be a nice supplement to the writing they do in their writer's workshop.

Web interface to view all the stories

Teachers thought it would be beneficial to have an easy way to view student stories. They expressed some frustration around the current setup, in which they need to consult each device individually in order to access students' work. They would prefer to be able to view stories from the teacher dashboard. This would be critical to teachers' ongoing, formative assessment of students.

Timing: earlier in the year and more spaced out

The concept of story sequencing (beginning, middle, and end) is taught starting at the beginning of the school year, so teachers would have liked StoryCoder at that time to supplement their instruction around that topic. Also, the teachers would have liked to space out their use of the app, e.g., over the course of several weeks, with non-use days in between.

Use of StoryCoder as an extension activity for other lessons

One teacher stated she would use StoryCoder as a spelling tool by having students program each character to say something related to particular words. This is merely one example of a possible extension activity. Creative teachers in the future may find other ways to adapt StoryCoder into instruction, and it may be beneficial to monitor or perhaps encourage novel uses of the app.

Classroom Usability Issues

Login and logout process is generally feasible but could be improved

At both sites, the classrooms used a shared set of iPads. Students logged in by first selecting their classroom or teacher's name and then selecting a student number that they are familiar with from previous use throughout the school year. At the end of class, many teachers asked their students to log out by going back to the app's home page or to the class selection page, in order to make it easier for the next student using that iPad to correctly log in to their account.

Logging in on the first day took more time than teachers were expecting. For instance, some of the devices that had been signed in to the teacher account the day before needed to be re-signed in during the start of Lesson 1. Most classrooms had the benefit of the on-site coordinator being present to help troubleshoot. However, future classrooms without this support may face a greater challenge.

Once students reached the class selection page, teachers stopped and went through this step carefully to make sure students were not selecting the wrong class or student. Despite these initial slow-downs, logging in went more easily in Lessons 2 and 3: most students readily knew their classroom/teacher's name and could select their student number and icon. To avoid logging in to the wrong student, teachers recommended not displaying the student icons until the class has been selected.

In the focus group, teachers wished the logout process at the end of a lesson was more streamlined. A teacher noted that it takes about 4 clicks to reach the class selection page and 5 clicks to reach the home page. During implementation, teachers usually instructed the whole class on this process, and it either took students longer than expected or teachers had to move quickly and trust that students had carried it out successfully. The end of a class period can become frantic when trying to manage a class set of devices, so changes to the logout process may aid classroom integration.

Audio presents challenges in a classroom setting

With a large number of students, the app's background music can pose a challenge for communication and focus. Teachers asked their students to turn the volume off or nearly all the way down; however, some devices' music was often still audible during class time. Also, having the volume turned down makes it hard for students to listen to the playback for the microphone commands that they record for their characters. As a result, students may find themselves having to switch back and forth between having the volume turned down (for general use) and turning the volume up (to engage with the microphone command).

There is a button on the app's home page and on the game selection page to toggle sound on and off, but this button was not observed being used or mentioned by participants. Also, it is not clear whether this button can be easily accessed during gameplay. For instance, if a student toggled this button to off, started to use StoryCoder, and then wanted to turn the sound on again to hear a microphone recording, it seems they would have to navigate back to the home page.

Pop ups have the potential to be distracting

There are several pop-up windows that students encountered: an advertisement for another game within codeSpark (a Snoopy-themed game), the in-app video introducing StoryCoder, and the gifts that give the player coins for returning on subsequent days. Students expressed some excitement at these pop-ups (in particular the gifts), but they also have the potential to be distracting in a classroom setting. For instance, shortly after students were signing into the app and when the Snoopy-themed pop-up appears, one student was observed playing the Snoopy game. Careful consideration should be given to what pop-ups appear for students and how they may impact the classroom setting.

Losing work was an issue for several students

Several students were unable to access their work. This includes not seeing a story created on a previous day, as well as the app quitting during gameplay and losing recent changes. For the issue of not seeing a story from a previous day, it is possible that some or all of this is due to students not using the correct iPad that contains their saved work. (The sets of iPads were numbered, and each day students were handed the iPad that matched their student number.) However, students and teachers seemed relatively adept at making sure students used the same iPad each day, so this finding shouldn't be entirely dismissed. Teachers were surprised that students seemed to accept this occasional loss of work and move on. However, this issue has the potential to set students back in other implementation models.

Text was sometimes unviewable while editing

Teachers said it could be hard to insert or edit text using the text command because the keyboard can block the text field. As a result, some students would be typing but couldn't view the words until they played the story.

Are teachers able to use the companion curriculum/resources to inform instruction and planning?

The implementation of StoryCoder consisted of a training session with teachers, and then three consecutive days of lessons with students in their classrooms. During the training session at the start of the study, teachers received copies of and walked through the three lessons and the accompanying worksheets. Teachers were instructed to follow the curriculum to the best of their ability and to let researchers know where the implementation diverged from the curriculum. Here is an abridged summary of the curriculum:

Lesson 1 – The Glitch and the Three Bears: A story is read and discussed, then students watch a tutorial video as they follow along on their devices.

Lesson 2 – Fox and Crow: A new story is read and discussed, and then students have time with the app. An accompanying worksheet helps with commands.

Lesson 3 – Story Magic: Students use a worksheet to plan their own new story, and then they have time with the app to create their story.

Teachers requested more extensive training

The training was a 1.5-hour small-group session with codeSpark and WestEd staff. This training showed teachers how to use StoryCoder and walked through the three lessons of the curriculum. Teachers thought the training helped them understand the basics of the app and the curriculum, but many felt underprepared for implementation. The main factor was time: they thought that the training wasn't enough for them to feel both comfortable with the app and knowledgeable about the curriculum, and it was a short window between the training and the first day of implementation.

> *"I was lost, and I worked on it for a few hours on the weekend and I still did not feel confident to teach it come Monday. I was a programmer before and I still couldn't figure this out. I did not feel prepared."*

A couple of the teachers said they were fine with the amount of training they received, since they were comfortable taking the app home and playing around with it independently. However, most teachers wanted more support. For instance, during class time, some teachers struggled to help students program events other than WhenTapped, as well as with adding more commands when the coding tray had become full. The teachers offered some ideas for how the training might be modified:

- More time for them to explore the app and materials independently and at their own pace.

- Increase the number of sessions to two or three, with time in between for practice and exploration.
- Provide a cheat sheet, handout, or similar resource that shows the most important commands and actions.

  "I would prefer a chart that says 'If you want to do this, press this. If you want to do that, press that.' As an adult learner, I don't have as much time to fuss around with things. Obviously, it was a good training, but something for the step by step would have been helpful, and some discovery time."

Length of the Three Lessons

The lessons were designed to last for 35 minutes. At one school site, the teachers largely stuck to this timeframe. During the focus group, these teachers stated that 35 minutes was not enough time to implement the lessons in an optimal way. At the other school site, many of the teachers were more flexible in the length of the lesson and would use StoryCoder for a full period (about 45–60 minutes). These teachers appeared more comfortable with this longer timeframe, in part because it aligned with their existing class schedule.

Lesson 1 – The Glitch and the Three Bears

Most teachers did not use the tutorial video, or they modified its use

Two of the eight classrooms showed the video as originally intended in the Lesson 1 curriculum. The other teachers either chose not to use video or, in the case of one teacher, simply forgot to. The teachers who chose not to use the video instead introduced several of the basic concepts to their students, such as the eat and walk commands. They did this by showing students on the overhead doc camera or having students follow their lead through a small step-by-step instructional sequence.

In the two classrooms where teachers showed the tutorial video, students followed along for the first few minutes. Then, many students began to work independently of the video. One teacher attempted to make the video easier for her students but eventually decided to forgo it: "I paused the tutorial, because it was getting too fast for my kids. So played it then paused again, and never got back because the kids kind of took off." The other teacher did something similar in that she initially paused the video in order to check in on the class' understanding, but then she let it play without further interruption. A few of these students were observed continuing to follow along with the video, but the majority of students did not experience the tutorial video as intended.

One of the teachers (who did not use the video as intended) wished that the video were modified to put focus on, not just the individual pieces, but a larger, completed story:

"The training video was very helpful, but what it really missed was an example of what a finished story looks like in StoryCoder so that we could visualize the final product. Whereas it was more of a sending off to 'Here's how you can use the software here, here's how you can press this here.' So you end up with a lot of facts about the program, of course you want to practice it, but to

actually see a final product—in other words, here's the beginning scene, the middle scene, and here's the end scene, and then you see how the characters inter-relate. That would have helped a lot for that training video."

A teacher at the other school site did exactly this—she made a completed story on her own ahead of time to show her students—and she felt this worked successfully.

The story was engaging, but its impact on students' understanding could be improved

The observations and focus groups suggested that students enjoyed the Lesson 1 story. For instance, students often laughed when the Glitch eats all the furniture, and teachers spoke positively about the story as a way to create initial interest with students.

By the end of the first lesson, students appeared to be engaged with the app and in learning the basic commands. However, for most students Lesson 1 was mainly exploratory, and the impact of the curriculum and tutorial video may have been limited. This is revealed well in a conversation between two of the teachers during the focus group:

Teacher 1: "My class thought that the Glitch was hysterical. They loved the story and they thought it was fun. And I also thought it was really like, 'Oh my gosh, that can be a real a thing that I can make.' So I thought there was high interest in then going in and seeing this scene in the app. Like I thought they thought this was special."

Teacher 2: "But did they approximate scenes from the story?"

Teacher 1: "They approximated actions, like they ate different food, they ate the table—they loved eating the table, that was funny. But I don't know if it helps with sequencing, like beginning, middle, and end."

This interaction suggests that Lesson 1 helped students mimic certain elements from the story, but it did not involve much storytelling. In this vein, a teacher suggested spending the first day of the curriculum more purposefully on free play, based on previous experience introducing students to educational computer science tools:

"Having spent the last year working on the elementary [computer science] curriculum, I know that often especially for the younger grades there's in general a day or two of almost free exploration of a tool before you do something… So they're not used to having a new tool in front of them AND having a task to do with that tool. Because that's how I did it last year and how [the previous teacher] did it the year before that. So they've had a couple years of doing it that way. So there was nothing you were going to do that was going to get them to do the story thing on the first day."

As this quote suggests, it may be fine that students' first day with the app is focused on ensuring engagement and basic understanding. However, this becomes a challenge when classrooms have limited time to use the app, or when subsequent lessons expect a certain level of prerequisite knowledge. The use of free play should be seriously considered for future implementations, and these data may help redesign the curriculum's trajectory to effectively and efficiently build students toward more complex use of the app.

Lesson 2 – Fox and Crow

Teachers were less complimentary of the Fox and Crow story compared to the Glitch and the Three Bears story.

Teachers thought the Fox and Crow story was less engaging. There seemed to be a less cohesive and productive relationship between the story and the students' tasks:

> *"I felt the commands in the story were a little simpler, so they didn't stick to the story as much… They had a really hard time dropping the cheese, because they kept clicking the bird and the bird kept jumping down—because you had to click the cheese, not the bird, to drop the cheese. So that was really confusing. And then they didn't stick with this one for very long. They went off and created their own thing… The dropping of the cheese was tricky, but it felt like okay you've dropped the cheese and moved the bird, now what do I do? Where does the story go from there?"*

Some students were disappointed they could not continue working on their story from Lesson 1. The teachers reported that some students would have preferred continuity in being able to contribute to the same story on more than one day.

One of the on-site coordinators explained that many students were confused by the flashing finger pointer in this scene, which points at the tree. When the finger pointer appeared for students, the teacher was helping them select the cheese to be eaten. Instead, many students clicked on the tree. The result—the fox eating the tree—was funny to a lot of the students, but the teacher thought it was a distraction. As a result, the finger pointer appears to have the potential to be either helpful or distracting depending on the context in which it appears.

Event-based coding was not well addressed in the lesson plan

One of the three objectives listed at the top of this lesson plan is "code a character to react to an event." However, neither the lesson plan nor the Fox and Crow Remix worksheet address how to accomplish this. Understandably, students did not typically use events other than WhenTapped. This would be a key area of improvement for future iterations of the curriculum, especially for addressing computer science concepts.

Lesson 3 – Story Magic

The process of planning a story was valuable to students and teachers

The Story Magic worksheet for Lesson 3 had students planning out what was going to be in their story: the characters, the setting, and commands to include in the beginning, middle, and end. During an observation of Lesson 3, a 2nd grade teacher used the Story Magic worksheet as intended in the curriculum (i.e., students had time separate from the app to plan), and as they used the app she reminded her students to think carefully about their story. This implementation was accompanied by some evidence of its potential effectiveness. First, for many students there was considerable overlap between what they selected on their worksheet and what was in their story. This suggests students were actively using the

worksheet to guide their storytelling. Second, at the end of class after the iPads had been put away, several students still had their worksheets out and were using them to discuss their stories together. While both of these observations are modest data points, they suggest the potential effectiveness of the Story Magic worksheet or similar approaches that have students envision their story outside of the app.

Teachers were similarly positive about the act of proactively planning one's story. One of the control group teachers hadn't yet used the Story Magic worksheet in class, but her input during the focus group spoke positively about the planning process:

> *"What would have benefitted my kids, which we do with [the computer science teacher], is write their codes first, then type it in. Because some of my kids were getting distracted by other things, and then their focus of 'Oh yeah, I'm writing a story' gets totally derailed because now they've found this new thing that they want to explore and then they don't go back to their story and things get erased and it's no longer a story, they're just pushing buttons. But if they first wrote out their sequence or had picture cards or something that they put in order, then they go in and follow what they wrote on their cards that they laid out, and then that will keep them on track and they can go play."*

Are students able to progress through StoryCoder in the classroom?

Students displayed a wide range of progress in using StoryCoder. By the end of Lesson 3, some students were creating carefully crafted stories using a dozen scenes, while other students were still at the more basic level of adding characters and programming them to walk and eat using a single scene. While some students may have came in with greater skill levels, the data presented below offers some insight into understanding students' progress and how future versions of the implementation might improve story progress for all students.

Initial progress in fundamentals was strong, but deeper engagement would require more time

As noted near the top of the section on the first research question ("Is StoryCoder feasible for elementary classroom use…), students eagerly jumped into use of the app starting on the first day. Their use continued to be consistently engaged on the second and third days. Students were using a wide variety of the seven commands and the many characters and backdrops.

However, by the end of the third day, teachers felt that their students did not make enough progress in crafting their stories.

> *Teacher 1: "I thought there wasn't enough meat to their stories. It did have beginning, middle, and ending, but each part was so brief. I don't think they had enough experience in developing it further. So I think a little bit longer with the application would have helped them have more meat in their stories. So basically they were just playing around with learning the little parts and what they could do."*

> *Teacher 2: "I have to agree. If we were to really use that program over the course of a number of weeks where they get beyond the goofing around with it, and then they get down how to do it, and then you can say, make a story… But first they have to have the tools to do it, and we're in process of still acquiring those tools."*

This quote suggests that future implementations may be able to successfully address the story sequencing concept if structured to give students more time (and possibly other supports) to more deeply engage in their stories.

Artifact Analysis

After the third day of implementation, a set of seven students' work in StoryCoder was randomly selected to be analyzed. From these seven students' work, thirteen of their stories were analyzed. The stories presented a mix of progress, from nascent to refined.

Most stories were brief, but a few showed evidence of more thoughtful storytelling

Many of the stories were well-populated with objects and characters, suggesting that setting up their scenes is a relatively easy task for students to engage in. This aligns with observations in the classroom, in which students readily added multiple characters/objects to their stories.

About half of the stories were very brief, with only a few commands added. A typical story in this category might have two characters, one or both of which would walk somewhere and then eat an object or another character.

Six of the thirteen stories included extra elements that hinted at an early progression toward storytelling. This included responsive dialog (e.g., Character 1: "hi my name is nozima"; Character 2: "and hi my name is y") or evidence that the student had a setting in mind for their characters, such as a story in which a character tells another character that "din[n]er is on its way" in front of food items resting on a table. When the teacher participants said that they wished students' stories had more "meat" to them, this may be an example of what they were referring to: students had begun to create something with a narrative intention in mind, but there wasn't enough time to develop it in one 35–60 minute lesson.

One of the stories was particularly long and appeared to be well thought-out by its creator. It contained ten scenes that showed a battle between characters on the left and right sides of the scene. The characters "fought" by walking over to the other side of the scene and picking up the other characters. The story included written dialog that added color to the story, such as a character saying, "we will save you boss."

As far as genre, only a few of the stories had enough content to make it clear what the story might be about. One story referenced the common fable The Three Little Pigs by using audio to mention "the big bad wolf." One student had two stories involving familiar daily life, such as getting ready for school and preparing for dinner.

WhenTapped was almost universally used to code commands

The WhenTapped event was used by all students, and for nearly all of their commands, with a few exceptions:

- One story used WhenSceneStarts to trigger two characters saying something.
- One story (same student as above) used WhenSceneStarts to have a character eat an object, but the object was no longer in the scene.
- One story included WhenSceneStarts and WhenEmotion as coding trays, but there were no commands added to them.

In all, only one story (the first bullet point above) used an event other than WhenTapped to successfully implement a command. This aligns with the classroom findings, in which events other than WhenTapped were not emphasized during whole class or one-on-one instruction.

Is StoryCoder an effective tool for teaching basic computational thinking and programming skills?

Consented Students and Prior Exposure to Coding Apps

Assessment Overview

To assess if StoryCoder impacted students' computational thinking, programming skills, or attitudes, WestEd developed a student assessment and survey specifically for this study and designed for pre-literate students. The assessment included items focused on measuring students' abilities with sequencing (putting things in the right order so that they make sense). The assessment consisted of 11 questions, two of which were used as worked examples to help students know the mechanics of answering a set of questions. The survey asked students about their attitudes towards storytelling (4 questions), exposure to pre-literate coding apps (3 questions on the pre-survey only), and thoughts about using StoryCoder (1 question on the post-survey only). Students responded to the questions about attitudes towards storytelling and thoughts about using StoryCoder on a 5-point Likert Scale using smiley faces to represent negative to positive emotion (i.e., Don't Like to Like, or Very Bad to Very Happy).

The assessment was administered by a WestEd researcher who read the questions to a class of students one at a time while students wrote answer choices on individual answer sheets. All students present on the day of administration took the assessment, but only consented student assessments were scored. As shown in Table 3, 93 students across the eight classrooms consented into the research study and had matched pre- and post-assessments. Kindergarten and 2nd grade subgroups are too small to reliably report without potentially identifying the participants. 1st grade treatment and control subgroups are large enough (44 and 21, respectively) so that a modest comparison of potential treatment effects can be made.

TABLE 3

Consented Students by Grade and Condition

Group	N
Treatment (Kindergarten)	12
Treatment (1st grade)	44
Treatment (2nd grade)	16
Control (1st grade)	21
Total	93

Prior Experience with Coding Tools

Three questions on the pre-assessment survey asked students about their exposure to pre-literate coding apps. Each question showed an image of a pre-literate coding app (Code.org, codeSpark, and Scratch Jr.) and asked if they had ever played that game based on the name or the image. Students answered yes or no by either circling a green check mark with the word "Yes" for having played the game, or a red "X" with the word "No" for not having played. Table 4 shows the responses to these questions and indicates a high level of prior exposure to coding apps. Students had the most exposure to Scratch Jr (83%), followed by codeSpark (60%), and the least exposure to Code.org (33%).

TABLE 4

Prior Use of Coding Apps

Have you ever used…	Yes
Code.org	33%
codeSpark	60%
Scratch Jr.	83%

Of the 93 consented students, only 9 (9.7%) answered "No" to all three questions, indicating that a high majority of students (90.3%) had prior exposure to at least one of the three pre-literate coding apps most similar to codeSpark. As mentioned in the Study Design & Methodology section, the two school sites had

implemented coding instruction in the current and prior school years. For some students this was the source of students' familiarity with the above coding apps (as well as other coding tools such as Bee-Bots), although for other students they may have used these tools outside of school.

All Kindergarten through 2nd grade students were able to complete the pre- and post-assessment in 20–30 minutes of class time. Students were relatively engaged in the assessment. Occasionally some students would get excited about a certain question. A handful expressed slight boredom, more so on the post-assessment. However, nearly all students were able to follow along with each question. Some students appeared tempted to look at their neighbors' answers. The WestEd facilitators and teacher regularly reminded students to stay focused on their own work.

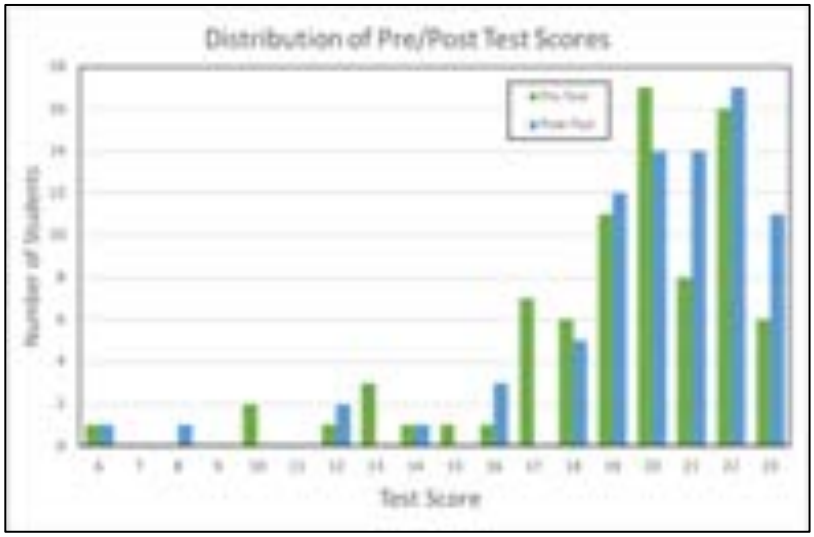
Assessment Results

Overall, students performed highly on the pre- and post-assessments

Figure 1 shows the distribution of pre- and post-test scores for all students in the 1st and 2nd grades with matched tests. Kindergarten student scores are not shown in this graph because an assessment administration error resulted in them not being asked question 11 on the pre-assessment.

FIGURE 1

Distribution of Pre/Post Test Scores



1st and 2nd grade students had a mean pre-test score of 19.21 and a mean post-test score of 19.99, both out of 23 possible points. These scores do not include points for the two worked example questions (items 1 & 8). The increased average and distribution of scores show slight student growth from pre- to post-test (+0.78), but the high pre-test scores provide little room for growth from the intervention.

Student performance on individual assessment items

Upon examination of each the test item, we see that most students received full credit on the majority of questions on the pre- and post-tests. Table 5 shows the maximum score, mean pre-test score, and mean post-test score for each item.

TABLE 5

Assessment Scores by Item

Item	Max Score	Pre Score Mean	Post Score Mean
1*	1	1	1
2	2	1.88	1.91
3	2	1.90	1.91
4	3	2.75	2.82
5	3	2.41	2.62
6	1	0.34	0.41
7	1	0.59	0.52
8*	1	0.99	0.99
9	3	2.77	2.95
10	4	3.40	3.56
11**	4	3.00	2.95

* Items 1 and 8 are worked examples that the students were guided in completing.

** An error resulted in Kindergarten students not being asked Question 11 on the pre-assessment. As a result, Kindergarten student scores are not included in the mean score for the pre- or post-test means for Question 11.

Questions 1 and 8 are worked example questions where the assessment facilitator demonstrated for students how to answer the questions. The intent of the worked example questions was so that students would know the mechanics for answering subsequent questions of similar type but increasing complexity. All students correctly answered question 1, and only 2 students had problems with question

8. One of these students answered question 8 wrong on the pre-test and the other answered it wrong on the post-test.

For questions 2 through 5, students were given a series of several pictures and had to draw lines to indicate their correct order in a sequence. The complexity of the questions increased to include more story images (from 3 to 5 images), and to include distractor images that were not part of the sequence. As the complexity of the questions increased, students did slightly worse on the questions but the most difficult question of this type, question 5, had a mostly positive pre-test score (2.41 mean out of 3 points). The mean pre-test scores for questions 2 through 5 indicate that students in this study largely already had a good understanding of sequencing.

Students showed the most difficulty with questions 6 and 7. Question 6 asked students to identify the image that happened "next" in a brief passage and question 7 asked students to identify the image that happened "before" a brief passage read to them. Mean pre-test and post-test scores for question 6 were 0.34 and 0.41 out of 1 point, while mean pre-test and post-test scores for question 7 were 0.59 and 0.51 out of 1 point. The majority of students did not change their score on these questions between the pre- and post-tests (81% no change for question 6, and 77% no change for question 7). Further analysis of these questions and the student responses is necessary to better understand the distractor images that students selected.

For questions 9 through 11, students were given a picture with several objects and characters, and the facilitator read a short passage. Students had to draw lines to show the correct sequence of where a character went in the picture. Similar to questions 2 through 5, questions 9 through 11 increased in complexity—including more story elements and distractors—as the questions progressed. Also similar to questions 2 through 5, students had high mean pre-test scores and had small increases on the post-test, except for question 11 with a 0.05 decrease. These questions also indicate that students in this study largely had a good understanding of sequencing prior to the study.

Both the treatment group and the control group increased their scores from pre to post

A series of paired t-tests were used to analyze changes in the mean score from pre- to post-test on student overall achievement and student achievement by experimental condition. The two classes of control students were both in 1st grade so the treatment effect was compared between 1st grade treatment students and 1st grade control students. Table 6 summarizes these findings.

TABLE 6

Assessment Scores Between Control and Treatment Groups

Group	N	Pre-Test Score		Post-Test Score		Change	
		Mean	STD	Mean	STD	Mean	p-value
Control Students	21	19.48	1.721	20.19	1.401	0.71	0.036
Treatment Students	44	18.41	3.787	19.21	3.776	0.80	0.017

Both groups showed high pre-test scores (19.48 for control and 18.41 for treatment) and significant increases (p-values < 0.05) on their post-test scores. Treatment students' post-test scores increased an average of 0.80 points, while controls students' post-test scores increased by 0.71 points. No statistically significant difference was found between the treatment and control score increases[1]. Therefore, the impact of the intervention as structured—three lessons using StoryCoder by students with coding app experience—did not appear to have any effect on students' sequencing abilities, as measured by the assessment.

Survey Results

Students were surveyed on their attitudes towards storytelling, using computers, and the use of StoryCoder. The latter question was only asked on the post-survey of treatment students.

Perceptions of storytelling for the treatment group went down slightly from pre to post test, but comparisons to the control group make this result less conclusive

Students were asked four questions about their attitudes towards storytelling and using computers. Table 7 shows the results for all treatment students (Kindergarten, 1st grade, and 2nd grade) and control students (1st grade only). Scores were converted from a 5-item Likert scale into scores of 1–5, with 1 equaling strongly disliking and 5 equaling strongly liking.

When asked if they like telling stories, treatment students responded somewhat positively (mean response of 3.83) prior to using StoryCoder but responded slightly less positively (3.43) after using StoryCoder. The control students responded slightly negatively (2.67) on the pre-survey and responded slightly more negatively (2.48) a week later. While the scores for both treatment and control groups went down slightly, the difference between their slight declines was modest.

[1] Given that students are nested within classrooms, a hierarchical linear model (HLM) was used to investigate the impact of codeSpark on student performance. We understand that the sample size at the classroom level is small. Therefore, the analysis using HLM was used for sensitivity analysis purpose. The results are presented in Appendix 1.

When asked about making things with a computer, treatment and control students responded positively (means of 4.22 and 4.45, respectively) on the pre-survey. Treatment students showed little change on the post-survey, while control students had a slight drop.

When asked about if they wanted to use a computer to tell a story, students responded mostly positive (3.67 for treatment and 3.57 for control). However, the treatment students showed no change in responding to this question after using StoryCoder, while the control students were slightly more positive one week after the pre-survey. Interestingly, both the treatment and control groups were slightly less positive about using a computer to tell a story than making things with a computer.

The fourth question used a similar 5-item Likert scale to ask whether students prefer hearing a story (score of 1), telling a story (score of 5), or somewhere in between. The treatment students were mostly neutral but had a slight preference for hearing a story, and there was little change from pre (2.67) to post (2.56). Control students had a preference for hearing a story, with a slight change from pre (1.30) to post (1.76). Given that the treatment and control groups had different starting averages, and that the control group's average changed without any intervention, it is difficult to form a clear conclusion on StoryCoder's impact on this question.

TABLE 7

Results for All Students from Pre- to Post-Survey

Questions	Treatment Students		Control Students	
	Pre Survey	Post Survey	Pre Survey	Post Survey
	Change		Change	
Do you like telling stories?[1]	3.83	3.43	2.67	2.48
	-0.40		-0.19	
Do you like making things with a computer? [1]	4.22	4.14	4.45	4.05
	-0.08		-0.40	
Do you want to use a computer to tell a story? [1]	3.67	3.70	3.57	3.95
	0.03		0.38	
Do you like to hear a story or tell a story? [2]	2.67	2.56	1.30	1.76
	-0.11		0.46	

[1] The range of scores ran from strongly disliking at 1 to strongly liking at 5.

[2] The range of scores ran from preferring to hear a story (1) to preferring to tell a story (5).

Post-Survey: Students reported positive emotions from their use of StoryCoder

All treatment students were asked on the post-survey how using StoryCoder made them feel. Students responded by selecting a frowning or smiling face on a 5-point scale from "Very bad" to "Very happy." Table 8 shows the student responses and an example of the responses students could select. 87% of students said that using StoryCoder made them feel "Happy" or "Very happy."

TABLE 8

Students' Perceptions of Their StoryCoder Experience

How did using StoryCoder make you feel?				
Very bad				Very happy
				
6%	1%	6%	16%	71%

Synthesis of Survey Results

The decreases in wanting to tell a story or use a computer from the first four survey questions are not surprising when considering the classroom observations and the sample of stories that were examined in more depth. These showed that many (if not most) students were at an early stage of their developing StoryCoder use. These data sources taken together with the survey results point towards students who are learning to use a new tool, possibly a little frustrated at times with their limited ability. However, students ultimately reported a positive experience using StoryCoder. This indicates students may continue to stay engaged in learning to use the new tool and may develop more positive affects towards storytelling and using computers if given a longer time to learn the program.

Teacher Feedback on Computational Thinking and Programming

Positive feedback on experimentation

Teachers liked how easy it was to play and experiment in the app. One teacher noted how quickly a user can undo certain actions by removing a character, object, or command. Another teacher commented that "there's no negative consequences. It is always positive. It's 'Oh, you made a mistake. Try something else.'

It's okay if they make a mistake." This freedom to experiment is important not only in implementing a new tool in the classroom, but it can be particularly useful when learning programming. For instance, the iterative process of programming—writing commands and testing them to make sure they work as intended—is a foundational experience that may greatly benefit early learners in this area.

Difficulty with events other than WhenTapped

Students in general did not regularly engage with events other than WhenTapped, and this may in part be due to some teachers' low comfort level with programming these other events. One example of this occurred when a teacher during Lesson 3 wanted to show the class how to program a character to respond to another character, possibly in response to a student's question on the matter. Instead of using the WhenEmotion event in her instruction, the teacher added a second line to the WhenTapped event. This action is used when a player wants to add more commands of that same event type, but the teacher interpreted it as a way to have one set of WhenTapped commands trigger another set of commands. After realizing that this method wasn't working, the teacher moved on from this topic in class. Later, in the focus groups, the teacher mentioned that another participating teacher had shown her how to do this previously, but in the moment it did not feel intuitive.

As noted in the section on the second research question, the Lesson 2 lesson plan does not adequately address working with events. Observations did not notice many students using events other than WhenTapped. This, along with the teachers' experience described above, indicate it would be beneficial to provide more support for teachers and students to program WhenEmotion and WhenSceneStarts events. This is particularly important as a step on the progression toward more complex programming.

Difficulty with the coding tray

Teachers thought the coding tray wasn't long enough, and they had trouble figuring out how to add more commands. This feature is already part of StoryCoder, but the teachers were not aware of it. Many students were quick to add many WhenTapped commands for their characters, so it is not surprising that many of them ran out of space. While some students discovered how to add an extra command line, some teachers and students were unsure of how to do this.

Engagement

Students experienced a high level of engagement while using StoryCoder. Examples of this include the following:

- In the focus groups, teachers talked about how much students loved the accessible creativity of picking their characters, adding objects, and animating their characters (especially eating things).
- Students were disappointed to stop at the end of the class periods.
- One student told his teacher that he downloaded the app at home to continue playing.
- A teacher commented that "the challenging kids who always get in trouble, they were really engaged and focused, and they did not get in trouble during that time."

While high engagement alone is not conclusive evidence of the app's effectiveness, it is a critical step toward introducing students to computational thinking and computer science concepts. At a basic level, high engagement supports instruction by allowing teachers to focus their instruction on students who most need support (e.g., during observations, the majority of students were excited to work independently and often helped each other when stuck, freeing up the teachers to roam around the room and address individual students' questions). At another level, the high amount of engagement means that future iterations of the curriculum can focus on *sustaining* and *directing* students' existing interest in the app—a much easier task than having to generate interest and engagement from scratch.

Recommendations

The following section presents overall recommendations for codeSpark around improving the functionality and effectiveness of StoryCoder based on the data collected. It is organized by the four research questions, plus a section on usability.

Recommendations – Is StoryCoder feasible for elementary classroom use such that teachers are able to integrate the app into their regular curriculum?

Refine the role of sharing stories as a class

Students were very excited to share their stories when given the opportunity. Currently, there is a 5-minute "Share and Tell" period at the end of each lesson; however, this process was often brief and ad hoc during implementation. A more thoughtful approach to how students share their stories may be a powerful motivator and a tool for students to reflect on changes to their story. Here are a few potential approaches:

- Incorporate the sharing process into a curriculum that includes a multi-day project, so that sharing can generate useful feedback that students can use to improve a story.
- Emphasize the sharing process in the teacher training.
- Consider differentiating the ways in which students share, depending on what is most effective for a particular grade level and the placement in the curriculum. For instance, sharing with an elbow partner or with a small group may be an effective way for students to quickly and comfortably share their stories. Gallery walks, as one school did, is another option. Also, whole-class sharing may be effective early in the curriculum to show students the "how tos" of sharing their story with others, as well as late in the curriculum as a summative and celebratory process.

- Consider tech constraints. The teachers in this study all had document cameras and projectors, which were helpful to share directly from an iPad to the class. However, classes without this technology should be guided on other ways to share stories.

Consider supports for non-fiction content

Teachers in both focus groups mentioned the growing emphasis on non-fiction reading and writing in their curricula. Fiction and storytelling are still essential to their teaching, but non-fiction supports could expand StoryCoder's value. Here are a few potential approaches:

- Create a curricular unit on a non-fiction genre of writing (e.g., a how-to book), and pilot it with a small group of classrooms.
- Leverage the camera feature to allow students to show evidence or examples from real life (e.g., plants in their neighborhood) or other media (e.g., pictures of historical figures in a book).
- Add characters, objects, and backgrounds that are less focused on fantasy storytelling and more on everyday life, science, or history. Consider grouping these into templates that allow students to easily select from them, or teachers to select which objects students have access to.

Enhance the teacher dashboard to allow for better review of stories

Stories are currently stored on individual devices, so teachers have no way of accessing them from their own computer or device. Teachers requested the ability to easily view all their students' stories, which may be critical to ensure they can assess student work and provide feedback.

- An additional idea is to allow teachers to easily view all written text from a student's stories. This avoids having to navigate through a full story and either click through all text commands in edit mode or click on all active objects in play mode. This ability would be particularly beneficial if codeSpark wants to promote StoryCoder as supporting student writing and integrating into existent writer's workshop instruction.

Consider other forms of student-created media

Several teachers supported the idea of allowing students to add drawings or other media to their stories, either by importing media or creating them in the app. For example, allowing students to turn a drawing into a background for their story. This feature may require a large amount of development, and it has the potential to distract from the core practice of coding commands. As a result, this recommendation should be considered carefully.

Streamline logging in and out

When logging in, teachers recommended not showing the student icons until the class is selected, as a way to discourage students quickly clicking on the wrong student. When logging out, consider quicker ways for a student to save their work and leave the device ready for another student to use it.

Be mindful of the microphone command and audio in classrooms

Many students were drawn to the microphone command feature, although the teachers thought it could be distracting. This high level of engagement is a positive finding in one sense, but it suggests the microphone may require a different integration into the curriculum. For instance, consider saving the microphone command for a later day in the curriculum. Also, consider giving teachers the ability to toggle on/off the microphone command for their students.

Similarly, the audio (music and sound effects) was both engaging and at times distracting. Teachers asked students to turn the volume off to avoid the app's background music, but with the volume off students can no longer hear the sound effects and their microphone playback. Here are a few potential approaches:

- As with the microphone, consider giving some control to the teacher over their students' audio settings.
- Set the background music's default setting to "off" for all teacher accounts, so that students must actively turn it back on. (Would not affect home users.)
- Add a toggle on/off button for the music and/or other sounds in places more easily accessible throughout the app (not just at the app's home page and on the game selection page).

Recommendations – Are teachers able to use the companion curriculum/resources to inform instruction and planning?

Make the lessons a full class period (about 45 minutes) instead of 35 minutes

Teachers who followed the lesson plans' 35-minute length wished they had more time. Meanwhile, other teachers decided to simply implement the 35-minute lessons during their full class periods (45–60 minutes). It may be easier to simply adjust the curriculum to this time frame than to trim the content in the existing lesson plans.

Let students work on a story over multiple days

Teachers expressed a desire for their students to be able to return to stories they worked on during a previous day. As a result, the curriculum could be edited to allow for this day-by-day building. A major upside of this approach is that is potentially allows the lessons to progressively introduce new commands and skills in the context of a familiar story. It also allows for an iterative cycle for creation, feedback, and edits—a familiar format to the writing process.

Continue using story planning activities; consider scene-by-scene story planning

The Story Magic worksheet in Lesson 3 was helpful for students to plan their stories outside of the app. Continue to incorporate this activity into the lesson plans, and consider other formats for this planning process. For instance, a three-panel layout may help students craft several scenes to a story, and this may support students' understanding of story sequencing.

Recommendations – Are students able to progress through StoryCoder in the classroom?

Longer period of time, ideally earlier in the year

Teachers wanted their students to have more time with the app, so consider a curriculum that includes more days and more spacing between those days. Also, teachers would have enjoyed having these lessons at the beginning of the school year, when they are covering story sequencing.

Encourage and plan for student-to-student peer support

Students readily discussed their ongoing projects and helped each other out during class time. This benefitted the students directly, and it freed up the teachers to address more challenging issues. Consider having teachers encourage and model this peer support for their students. This peer support might also be added more conscientiously into the lessons.

Create a separate tutorial space that is specifically aligned to the curriculum

Similar to how the video tutorial aimed to introduce students to particular skills and features, a self-paced area in the app may help new students become comfortable in a slightly controlled setting. This may help insulate the onboarding process from general-use features that are more challenging.

Create short user tutorials that are easily accessible

Teachers raised the idea of adding short and ready-at-hand tutorials within the app so that students have a resource when they need to know how to do something, perhaps when a teacher is not available. For instance, a 15-second video to show how to use a command could be accessed from a menu. An example of this would be a video accessible in a menu at the top of the screen.

Recommendations – Is StoryCoder an effective tool for teaching basic computational thinking and programming skills?

Progressively unlock students' access to commands

Based on previous experience with similar tools, one participant suggested limiting students to certain commands when first using StoryCoder, so that students learn the most important actions first before unlocking the additional commands with further use. This progression could be built into the app, possibly with a structure unique to school-based users. Another option is to give teachers the ability to include/exclude commands in order to focus their students on particular skills and features.

Address when the object-to-command connection is broken

Currently, if a player writes a command for a character to eat a piece of cheese, but then later deletes the piece of cheese, the character's eat command remains unchanged. This has the potential to hinder students who are adding/deleting many characters and commands but not closely managing these various parts. Here are a couple options to consider:

- Highlight or flag these broken connections in the coding tray.
- Include a pop-up message that only appears when deleting objects that are linked to a command.

Recommendations – Usability

Limit pop-ups in the classroom setting

The pop-up messages that appear during use of the app (i.e., the daily coin gifts, the ad for the Snoopy game, and the intro video to StoryCoder) have the potential to be either engaging and distracting. Some students were excited by them, but others were sidetracked. For example, one student began playing the Snoopy game for several minutes before switching back to the task at hand. Another teacher had to give extra directions to the whole class to close the pop-ups. Consider disabling or limiting these pop-ups for classroom accounts.

Fix the speech bubble

Teachers noticed that sometimes when students were typing for the text command, the keyboard covered the speech bubble where the text appears. Consider fixing this to where the speech bubble is always visible when typing in a text command.

Add an undo button

Several teachers would like to see an undo button to avoid students being stuck with unintended actions, such as deleting commands and characters.

Make the eraser button one-touch

Currently, once the eraser button is selected, it will erase anything users tap until it is turned off. Two teachers suggested making the eraser into a one-touch button, in that once you tap the character or object you want to delete, the eraser becomes unselected. The teachers thought this change would align with other tools and would avoid students unintentionally deleting characters and objects.

Fix saving, perhaps by auto saving

Some students had issues with saving their stories, and this has the potential to seriously hinder classroom use. Consider having students' stories be automatically saved at frequent intervals, or add a more clear process for students to explicitly save their stories. On the other hand, it is possible that these saving issues stemmed from a problem on the backend of the app's programming, in which case a fix to the backend may be sufficient.

Add space to the coding tray

It can be difficult to scroll through commands without accidentally dragging a command into the scene and potentially deleting it. This is especially the case if the coding tray is filled with commands. Consider

adding a little extra space for the coding trays to be scrolled, for instance on the right side of the coding tray.

Fix the unintended appearance of the purple Home and Play buttons

Sometimes the purple bubble with the Home and Play buttons remains on screen in Edit mode, which blocks the lower portion of the coding tray and the upper half of the command buttons. (See Figure 2 below.) This occurred when a story ends and the purple curtains cover the screen, and by then pressing the orange Edit button in the top right corner.

Figure 2. Purple bubble with home and play buttons appears unintentionally.

Delay text at the beginning of a scene

When using the WhenSceneStarts event in the first scene, text can appear before the curtain has finished moving off the screen. (See Figure 3 below.) Consider delaying any WhenSceneStarts event to begin as soon as the curtain has cleared from the screen.

Figure 3. At the beginning of a story, text appears before the curtain splits.

Streamline scene selection when there are many scenes in a story

While in Edit mode, after clicking on the purple scene button, it displays the scenes starting at scene #1—even when there are many scenes in the story and when the current scene being edited is higher than the scenes visibly listed. This means that a user has to scroll to get to adjacent screens or to hit the "+" button to create a new screen. Instead, consider showing the current scene in the middle of the scene icons when a user presses the purple scene button.

Conclusion

This feasibility study provided a substantial amount of formative data to help StoryCoder become a more useful tool for early elementary teachers and students. It suggested that StoryCoder can engage a wide range of students in the process of storytelling and basic computer science concepts. At the same time, the data suggests that changes to the curriculum could help to better translate this engagement into more complex storytelling and programming.

The pre/post assessment did not show any statistically significant changes in students' ability to complete sequencing tasks, but given the small sample size and prior experience of the students, additional research would be needed to further explore this question.

Some of the limitations of student outcomes may be attributable to the constraints of the study: teachers felt like they could have used more training, and the implementation was only three lessons long—not enough time to develop more sophisticated storytelling, according to the teachers. With additions to the teacher training and a longer period of implementation, students will be better positioned to learn the features of the app and to apply that knowledge to the creation of their stories and learn computer science concepts.

Appendix 1

Hierarchical Linear Model of Student Assessment Scores

Adjusted mean differences on the researcher-developed codeSpark assessment scores show that the treatment group's scores on the post-test were similar on average to those of the control group (point estimate of -0.12). This difference was not statistically significant (at the 0.05 level) after accounting for differences in baseline test results.

TABLE XX

Analysis of Student Outcomes

	Adjusted Mean					
Measure	**Treatment (Standard Error)**	**Control (Standard Error)**	**Difference (Standard Error)**	***p*-value**	**95% Confidence Interval**	**Sample Size**
Researcher-Developed Assessment	19.48 **(3.78)**	19.60 **(1.40)**	-0.12 (.48)	**.80**	**-1.07 – .82**	**65**

Note: Data were regression-adjusted using multi-level regression models to account for differences in baseline characteristics and students nested within school.