20. StoryMode: An Exploratory Test of Teaching Coding Within ELA Projects

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Abstract: Teachers and parents agree that computer science education is a necessary discipline to learn and want to see it in their schools and homes. Children who are exposed at an early age to computational thinking and STEM curricula are more likely to enter technical fields, hold fewer gender-based stereotypes about STEM, and show many other beneficial outcomes. However, teachers do not have the time, budget, or feel qualified to introduce a coding curriculum into their already overwhelming schedules. The current study explores an educational tool designed specifically to teach computational thinking and coding skills to young children ages 5 to 9 years old that may overcome these barriers. Using a game-based, block-based programming environment, StoryMode uses a visual environment that makes learning programming easy, fun, and engaging. Children create multiscene animated stories using code in StoryMode. The platform was created such that any teacher, with or without computer science knowledge, can easily and confidently use it in his or her classroom and integrate it with an English Language Arts (ELA) curriculum. The results of this exploratory study found that across 10 classrooms, StoryMode was interesting and engaging for young children, easy for teachers to implement, and a potentially useful teaching tool for computational thinking concepts. Teachers were especially excited for its future use and integration into lessons beyond ELA, including social studies and science. Overall, this research suggests that StoryMode may provide a way to overcome many of the time, resource, and implementation barriers to computer science education.

The Importance of Children's Learning Coding and Computational Thinking

Computational thinking and its foundation in STEM are our children's future. Jobs in computing are increasing twice as fast as in other occupations, and 58% of new STEM jobs are coming from computer science (Bureau of Labor Statistics, 2019). The greatest advancements, innovations, new products, and new industries have been derived from STEM and the minds of those interested in its areas of research. It is therefore imperative that we encourage the interest, confidence, and knowledge of STEM skills in our children. The elements of computational thinking (e.g., sequencing, looping, events, conditional logic, variables, and algorithms) are particularly beneficial when introduced to children at a young age. Children who are exposed at an early age to coding and computational thinking demonstrate fewer obstacles entering technical fields (Madill et al., 2007) and fewer gender-based stereotypes regarding STEM careers (Metz, 2007). Increased knowledge of computational skills in early childhood is also associated with better problem solving, decision making, basic number sense, language skills, and visual memory (Clements, 1999; Flannery et al., 2013).

Despite the many benefits of studying and working in STEM, there are few educational technologies created for early childhood that focus on coding and computational thinking skills (i.e., under the age of 8 years old). Creating this type of educational technology for young children comes with numerous challenges. First and foremost, many 5- and 6-year olds cannot yet read, and therefore, a strict syntax or text-based program would be frustrating and uninteresting. Second, young children learn more effectively when the skill is introduced with an appropriate level of complexity to support their reasoning and executive function skills (Clements & Sarama, 2011). Third, girls remain less interested in STEM careers and associated games (Valian, 2006). There unfortunately remains a gender stereotype for STEM subjects such that even as early as second grade, children believe that math is for boys both implicitly and explicitly (Cvencek, Meltzoff, & Greenwald, 2011). And researchers believe this gender stereotype persists because of lack of experience with

STEM-related activities (Master, Cheryan, Moscatelli, & Meltzoff, 2017). Overall, an effective educational technology that teaches coding and computational thinking for young children needs to consider their developmental and cognitive capabilities, while also still capturing the interest of both boys and girls and their many different views of what is fun to play.

Barriers to Teaching Coding in the Classroom

In a survey of 504 K–12 teachers by YouGov in November 2018, 88% of teachers and educators agreed that computer science is critical for students to learn (Microsoft Education Team, 2018). However, many teachers do not include computer science instruction in their classrooms. The teachers surveyed explained the many reasons for not implementing coding, such as its not being a part of the current curriculum, insufficient funding, and a lack of trained and qualified computer science instructors. Moreover, only 20% felt confident in their own understanding of computer science education, and thus did not feel they could teach it themselves. In a Gallup study during 2014, principals and superintendents of schools and districts that do not offer computer science classes said it was because of limited time to devote to classes that are not tied to testing requirements and low availability/budget for computer science teachers (Busteed & Sorenson, 2015). In short, an effective technology for teaching coding also needs to overcome the sizable barriers to computer science instruction in early elementary years: Teachers do not have the time, money, or feel qualified to introduce a coding curriculum into their already overwhelming schedules.

Using Story Lines in Games as a Teaching Tool

There has been positive evidence that instruction via games can affect young children's development of coding skills (Fessakis, Gouli, & Mavroudi, 2013; Strawhacker, Lee, & Bers, 2017). For example, Strawhacker and colleagues examined 222 K–2 students' performance on a series of assessments designed to measure computational thinking concepts after lessons on ScratchJr (Bers & Resnick, 2014) programming. Their results showed that K–2 students were able to perform well on areas of symbol decoding and sequence comprehension, as well as on areas of debugging and goal-oriented coding. The next step to getting young children to learn coding concepts with games is to find one that captures the interest of both boys and girls, and that can be implemented easily by teachers in the classroom.

Our study explores the idea that this can be done with pretend-play, story-creating games. Research suggests that young children are not only more interested in fantasy play and stories over realistic ones, but they also learn better from such content. For example, a study of preschoolers' knowledge of new vocabulary words showed greater gains when storybooks and play content were creative and fantastical versus realistic (Weisberg et al., 2015). Pretend play is also a useful form of behavior for learning in young children and has shown to be beneficial for cognitive skills, including symbolic thinking and counterfactual reasoning (Weisberg et al., 2015). This type of learning should benefit both girls and boys since they engage in sociodramatic play with equal frequency, but with varying topics (e.g., boys make use of tools and vehicles while girls tend more toward home and school; Edwards, Knoche, & Kumru, 2001). The game *Alice* (Pausch, 1999) is a 3D interactive graphics game and uses storytelling to teach coding; however, it is created for cognitive abilities at middle-school level and beyond. Despite using more advanced algorithms and techniques than would be applicable to young children, a study of the *Alice* game found a strong benefit in teaching these concepts through engaging and interesting storytelling content (Cooper, Dann, & Pausch, 2000). The use of stories is also a versatile teaching tool that can be applied to book reports, personal narratives, and opinion projects.

StoryMode as a Coding Game Within ELA

Creating stories is an engaging and potentially effective way for young children to learn computational thinking and coding concepts and may also overcome the many implementation barriers for teachers. In order to test this idea, the current study used a new teaching tool called StoryMode. This patent-pending (Shochet, 2016) game-based, block based programming environment was designed for children ages 5 to 9 years old to learn coding and computational thinking skills while using a story line. By using a block-based programming environment, the game enables students to code using icons rather than traditional text commands. The idea behind visual programming is to make learning easier by removing many of the challenges posed by traditional languages (e.g., syntax, variable initialization; Werntrop & Wilensky, 2015). Thus, the game can be played regardless of age, language, or country. It focuses on translating complex computer science concepts into a block-based or coding language format that maintains sufficient clarity and simplicity for young children to understand. The characters are controlled by the players through blocks that represent actions such as walk, jump, or throw an object. The players then drag commands from the library of actions to the code tray, the interface where events occur through touch. When they tap the character, the commands they have selected (walk, jump, etc.) allow them to reach their goal.

Within StoryMode, children can choose from multiple story templates with different setups to get started, and then each story can include several linked scenes. Students take on the role of "author" using design skills to set up the scene and coding skills to move and create interactions between characters and objects for each scene of the story. StoryMode provides a variety of characters, props, backgrounds, and emotions for children to add to each scene. Children are able to position and arrange objects in Edit mode and to program each object to follow certain commands. They can code a character to move or speak when tapped or as soon as the scene begins. A voice-over command allows the children to record their own voices and then to associate their speech with a character or object in their stories. Children can also use code to program their characters to trigger back-and-forth interactions and conversations. And it is important to note that the open-ended setup of StoryMode allows teachers to choose how best to use the tool. Any teacher, with or without computer science knowledge, can implement it into his or her classroom and integrate it with the current English Language Arts (ELA) curriculum (e.g., book reports, narratives).

Research Study

The current study is a qualitative exploration of StoryMode and its potential as a feasible and versatile tool for bringing coding into early elementary classrooms. The following research questions were addressed:

1. Are first- and second-grade *students* able to progress through StoryMode, and do they find it easy to use and interesting/engaging?
2. Are *teachers* able to incorporate StoryMode into their classrooms, and are they interested in using it in the future in order to bring coding concepts into ELA lessons?

Participants

The study involved teachers (N = 10) and students (N = 94) from eight classrooms across two elementary schools in the San Francisco Unified School District. At each school, there were four classroom teachers and one on-site coordinator who participated. The on-site coordinators had multigrade support roles at their schools with a focus on technology instruction. Only students with parental/guardian consent participated in the study (see Table 1). The two school sites

varied in demographics: School A had 84% on free or reduced lunch, 70% English learners; School B had 34% on free or reduced lunch, 24% English learners. Both school sites had implemented coding instruction in their current and prior school years.

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

Table 1. Description of participants.

Method and Data Collection

Teachers first attended a 1.5-hour training session on the use of StoryMode. The following week, they used StoryMode on three consecutive days during their ELA lessons. Lessons lasted 35–60 minutes. Teachers were provided the three ELA lesson plans and curricular materials for each day that corresponded with the features of StoryMode (see details below).

Two research assistants observed each teacher's classroom during these lessons at least once to gather qualitative assessments. 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 StoryMode was being used and received by the students. At the conclusion of the study, teachers participated in a one-hour focus group to discuss their reflections on the game and their experience using it in the classroom. A sample of students' stories created in StoryMode was also analyzed to see the tangible products of students' work. These stories were analyzed using a protocol covering six themes: Sequencing, Storytelling, Genre, Language Use, Use of StoryMode Features, and Other (anything of interest that did not fit in the above categories). In addition, students were asked at the end of the study about their emotional response to StoryMode on a 1–5-point Likert scale (using frowning and smiling faces): "How did using StoryMode make you feel?"

Lesson Plans

A brief three-lesson companion curriculum was provided to teachers with StoryMode as an example of how this educational technology could be used with ELA instruction. The curriculum itself was not the focus of the study, but rather, allowed teachers to incorporate StoryMode into their day without having to develop their own lesson plans. These three lessons were developed based on common ELA writing programs in California.

- In Lesson 1, students are introduced to StoryMode by watching and listening to a version of "Goldilocks and the Three Bears" that includes StoryMode characters. They then discussed story structure, creative elements, and review how the coding in the example was done. Students then viewed a tutorial of StoryMode. After a discussion of this tutorial, students begin creating "Goldilocks and the Three Bears" using StoryMode and a worksheet that guided the creation of a story arc.
- Lesson 2 moved students into more advanced coding with StoryMode. A different popular children's story was read, and the teacher discussed how the story could be changed to be more funny or interesting. Students then accessed StoryMode, where they were provided with one complete scene and one scene with images only, along with a worksheet of challenges and ideas for coding their own version of the story.
- Lesson 3 tied the coding back into the story making. Students created a three-scene story in StoryMode with a few instructions to help them through the first scene (e.g., replace the characters on the screen with your own characters, replace one of the events with an event you haven't used before, add a new character that interacts with one of the old characters). Students then completed the rest of the story on their own.

Results

Are First- and Second-Grade *Students* Able to Progress Through StoryMode, and Do They Find It Easy to Use and Interesting/Engaging?

Classroom observers agreed that students were able to readily pick up the fundamentals of the game and were happy to share their stories at the end of class. Teachers noted that starting on the first day, students began using the game 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." The children loved picking their characters, adding items, using the different commands, and most wanted to continue working in StoryMode despite the lesson's coming to an end. They were very happy to share their stories at the end of class. Observers noted that all or nearly all the students raised their hands 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. In the focus groups, teachers noted how much students loved the accessible creativity of picking their characters, adding objects, and animating their characters (especially eating things). Overall, StoryMode appears to be easy to use by first- and second-grade students, while also an interesting game that kept children's interest throughout multiple lessons. The latter was also confirmed quantitatively: 71% of students felt "very happy" using StoryMode (see Figure 1).

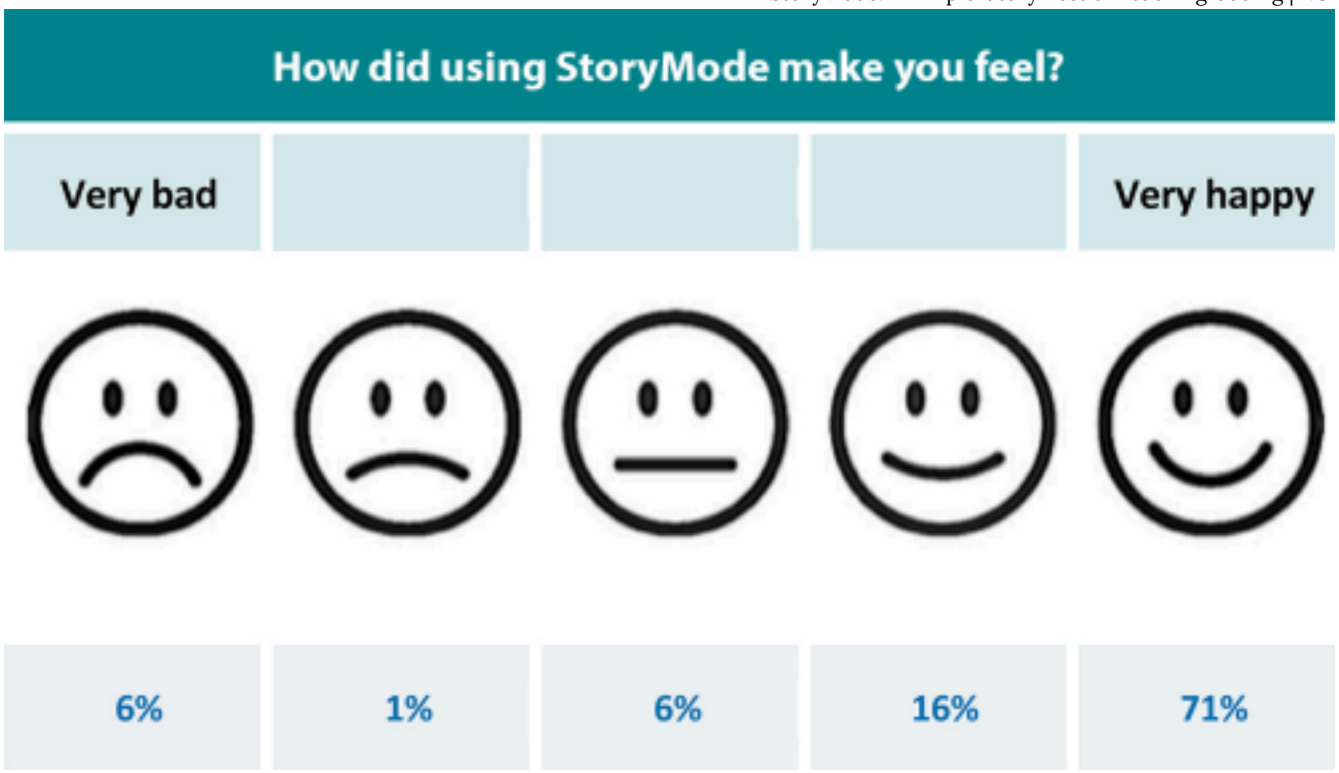

Figure 1. Assessment of student Interest in StoryMode.

Are *Teachers* Able to Incorporate StoryMode Into Their Classrooms, and Are They Interested in Using It in the Future to Bring Coding Concepts Into ELA Lessons?

In the focus groups, teachers were complimentary of how StoryMode could be used to reinforce their teaching around the ELA curriculum of story building (i.e., the structure of beginning, middle, and end), and they wanted more time and more ways to incorporate StoryMode into their writing curriculum (e.g., "how to" books, science writing, book reports). One teacher said she would use StoryMode in the future as a spelling tool by having students program each character to say something related to particular words. Two additional teachers commented on how the basic format of the game'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." Teachers also commented on how they were pleased with how StoryMode could engage their students, particularly given children's various skill levels. One teacher said, "The challenging kids who always get in trouble, they were really engaged and focused, and they did not get in trouble during that time." Teachers liked how easy it was to play and experiment in the game. 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 OK if they make a mistake." They agreed that this freedom to experiment is important when implementing a new educational technology into the classroom. Altogether, teachers thought StoryMode is an interesting and exciting tool for incorporating coding concepts into many different types of lessons

Story Analysis

After the third day of implementation, a set of seven students' work in StoryMode was randomly selected to be analyzed. From these seven students' work, 13 of their stories were analyzed. The stories presented a mix of progress, from nascent to refined. Many of the stories were well populated with objects and characters, suggesting that setting up their scenes is a relatively easy task for students. 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 13 stories included extra elements that hinted at an early progression toward storytelling. This included responsive dialogue (e.g., Character 1: "hi my name is claire"' Character 2: "hi my name is arad") or evidence that the student had a setting in mind for the characters. The results of this story analysis suggest that students were able to navigate StoryMode and use coding skills to create stories.

Discussion

Telling stories is an engaging and fun way for young children to learn computational thinking and coding concepts that can overcome the many barriers of bringing coding into the classroom. The current study examined the idea of using a storytelling coding game (StoryMode) as a teaching tool for children to learn ELA along with coding concepts. The platform was created such that any teacher, with or without computer science knowledge, can implement it into his or her classroom and integrate it with ELA curriculum. Students can tell their own stories and let their imaginations flourish through coding or follow a predesigned curriculum that corresponds with an ELA lesson. Teachers found StoryMode exciting and useful, and they could see it extended into other subjects, such as science and social studies. Showing high teacher interest, student engagement, and ability to cross into ELA curriculum are critical first steps toward finding a tool that introduces students to computer science concepts. Future research will quantitatively test the game's efficacy in teaching specific computational thinking skills, such as sequencing, events, loops, and algorithms.

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