Translating Roberto to Omar: Computational Literacy, Stickerbooks, and Cultural Forms

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ABSTRACT
We present the design and evaluation of an interactive storybook to support emerging computational literacy skills for preschool and early elementary school children. We structured our designs to take advantage of existing language literacy practices between parents and children around the cultural form of a children's storybook. We evaluated our design with 14 families from two distinct cultural backgrounds: families from the United States Midwest and families from Riyadh, Saudi Arabia. Our findings describe ways in which parents support and structure children's programming activities, and how parental involvement varied across the two groups.

Categories and Subject Descriptors
H.5.2. [Information Interface And Presentation]: User Interfaces – Interaction styles;

Keywords
Children; computational literacy; storybooks; tangible interaction; computer programming; stickers; cultural forms; design; learning.

1. INTRODUCTION
Developing a computationally literate citizenry is seen as an increasingly important goal of modern society [2, 8, 22, 25]. In this paper, we present the design and evaluation of a storybook intended to support computational literacy skills for preschool and early elementary school children. The technology combines a paper storybook with computer programming activities that children complete by adhering stickers to the pages of the book (Figures 1-6). The programs then control an interactive digital character that appears on the screen of a smartphone or tablet computer.

In many parts of the world, parents and young children read storybooks together [1, 4, 28]. Such family reading activities have been shown to promote early literacy skills, reading achievement in elementary school, and positive attitudes towards books in general [5, 28]. One of the reasons we chose to embed computational literacy activities in a storybook has to do with the support that parents provide to children when they read together. These support activities include making spontaneous connections between the text of the book and the world of the child; providing emotional encouragement; and tailoring the reading session to a child's needs and abilities [4, 5, 6, 23, 24]. Through the use of a storybook, we hope to cue these valuable language literacy practices and to provide a framework for parents to scaffold their children's emerging computational literacy skills. We intentionally chose to use a paper sticker book (rather than an electronic book) because we believe that a physical book presents a *cultural form* that is less ambiguous to parents than an app on a tablet computer. We discuss this hypothesis and the role of cultural forms in design below.

Storybook reading is also a cultural phenomenon, with practices varying from parent to parent, household to household, and region to region. Some families view storybook reading as a pleasurable activity, while others might think of it as more of an opportunity to teach literacy skills or to impart important life lessons [1, 4]. In selecting a storybook as our source cultural form, we were aware that parental activities could vary dramatically from one family to the next. Thus, to evaluate our prototype we recruited families from two regions (8 families from the U.S. Midwest, and 6 families from Riyadh, Saudi Arabia). In so doing, we hoped to understand dimensions along which parental involvement might vary and to improve our designs in light of diversity.

In this paper we review related work and provide a theoretical background for our design. We then describe the design and implementation of our prototype. Finally we present an evaluation with parents and children. Our findings describe a variety of ways in which parents support their children's programming activities.

Figure 1: Children reading a prototype of our stickerbook.

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2. RELATED WORK

The integration of storytelling, physical materials, and interactive digital systems has a rich history in the human-computer interaction literature. One strand of research has involved the creation of immersive storytelling environments (e.g. [3, 21]). For example, *StoryRoom* [21] is an immersive environment in which children can create and "program" their own stories using interactive physical elements. To program StoryRoom, children use a magic wand to specify the relationships between various interactive story props (sensors and actuators). Another strand of research has explored children's storytelling through the use of interactive "companions" such as stuffed animals and child-friendly robots [2, 7, 10, 30, 32]. Some of these projects enable children to program elements of the interactive companion to endow them with sound, emotional expression, and movement [2, 32].

Several projects have also explored the use of physical and digital storybooks as a context for communication, storytelling, and learning with children [6, 9 10, 12, 14, 23, 24, 26, 31]. One relevant example is Sylla et al.'s *t-books* system that combines a physical book with electronic sensors [31]. As children read t-books, they can place picture cards into slots in the book to interact with the narrative structure. Another project is Chang and Breazeal's *TinkRBook*, a digital storybook that, among other things, allows children to explore relationships between text and imagery in a story [6]. In introducing their system, Chang and Breazeal pose the questions: "What if books were 'tinkerable'? What if children could actively explore and modify a story, through voice and touch, to dynamically explore meaning as conveyed by the relationship of text to illustrated concept?" As part of their project, Chang and Breazeal observed families reading together and noted the variety of interactions between parents and children that enriched the storytelling experience [6]. *StoryFaces* is another storybook environment in which children record emotional expressions through a digital camera that then become part of the storybook's illustrations [26].

Several recent projects have explored the use of storybooks as a context to improve remote communication between distributed family members. *Video Play* [12] is a system through which children and long-distance family members act as characters in children's storybooks by integrating video chat streams directly into the storybook illustrations. *Family Story Play* [23] and *Story Visit* [24] augment video conferencing so that remote adult family members can see and hear each other while reading the same connected storybook. Analysis of families using these systems revealed that many of the common reading enrichments that occur between adults and children carried through into the remote sessions. Finally, Freed et al. presented the idea of using electronic stickers to create personalized remote communication interfaces in *I/O stickers* [13]. Children can attach I/O stickers to special greeting cards to invent ways to communicate with long-distance loved ones with personalized connected messages. This was one of the inspirations for our current stickerbook design.

Over the past forty years researchers have created a variety of programming environments to introduce computational literacy skills to children [7, 8, 16, 17, 19, 21, 22, 31, 34]. One interesting example that combines storytelling and computer programming activities is *Storytelling Alice* [17]. Kelleher et al. designed this programming environment to engage middle school girls in the creation of interactive narratives with 3D virtual characters. Finally, tangible programming environments attempt to incorporate playful physical materials into the process of creating computer code (e.g. [16, 19, 21, 34]). Unlike much of the prior work in tangible programming, our stickbook design employs the use of inexpensive materials (paper stickers) that lend themselves to mass production and distribution.

3. DESIGN PROCESS

In this project we are attempting to create an informal learning activity that supports emerging computational literacy skills in a fun and engaging way for preschool and early elementary school children. The activity ideally provides a structured introduction to basic computer programming skills while at the same time allowing for open-ended exploration. Finally, regardless of parents' prior experience with computer programming, we hope to encourage productive parental involvement to tailor the activity to a child's needs and experience level.

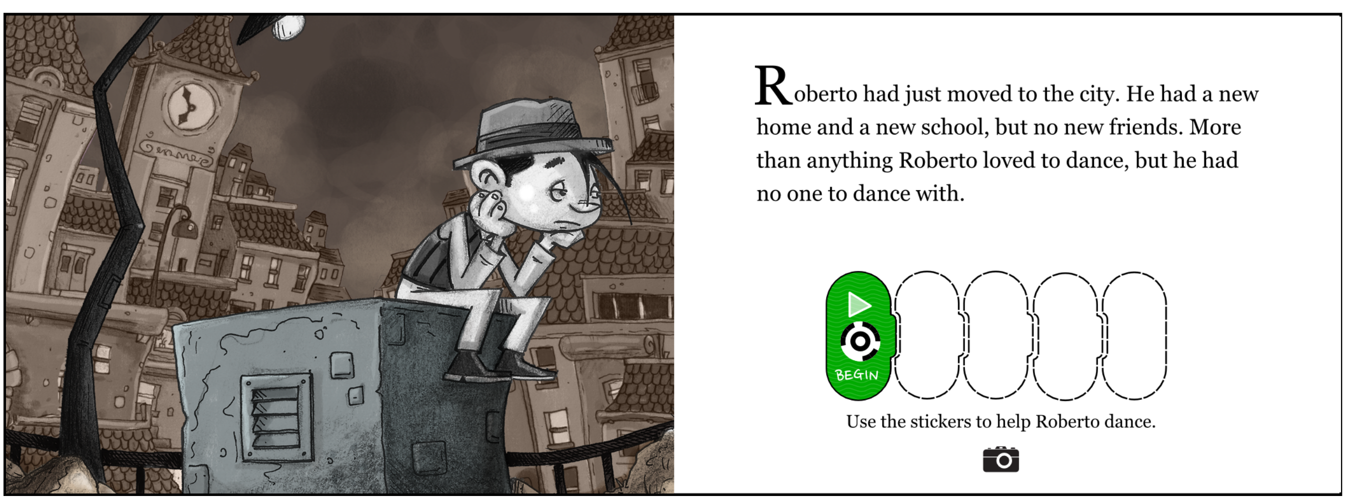

Figure 2. Page from the *Roberto* stickerbook. Illustrations by Igor Ivanovic (brainlesstudio.blogspot.com)

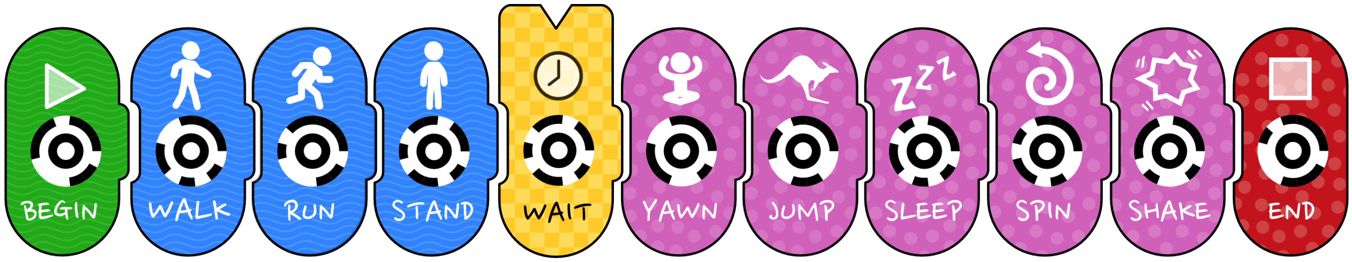

Figure 3. A collection of stickers that children can use to create programs for Roberto.

3.1 Designing from Cultural Forms

Our design process was guided by the idea of building novel interactive systems based on existing *cultural forms* [15]. By cultural form, we refer to historically elaborated social constructions that are inherently linked to social practices and activities [27]. Examples include things like counting systems, games, tools, monetary currency, and so on. Cultural forms can involve physical artifacts (as in currency systems or games like chess) or they can consist entirely of patterns of activity (as in games like hide and seek). For this project, we built on two cultural forms: children's storybooks and stickers.

The idea of designing from cultural forms was inspired by the notion of *cultural funds of knowledge* [20], Lee's *cultural modeling design framework* [18], and Stevens' [29] ethnographic research on children playing video games together in homes. Creating interactive systems based on cultural forms has two advantages. First, cultural forms are inherently linked to social practices. In other words, an artifact like a storybook is nothing more than a few sheets of paper and cardboard in the absence of recurrent, socially organized activities that give it meaning. A storybook is a storybook because a child knows that she can pull it off a shelf at bedtime, sit with it on her mother's lap, and read it (or have it read to her). And, of course, the act of reading involves far more than decoding symbols on the page and reciting the words out loud. Parents and children have elaborate rituals that include making spontaneous connections between the text and the world of the child, pointing out characters and objects in the illustrations, asking and answering questions, providing emotional support, and tailoring the reading session to the child's needs and abilities [1, 4, 5, 6].

This leads to a second advantage, which is that the practices surrounding cultural forms involve a variety of social, emotional, and cognitive resources. If we can successfully evoke source cultural forms in our designs, there is the possibility that users will bring these practice-linked resources to bear on the novel activities that our interactive system supports (in our case computational literacy activities). Even though cultural forms have a degree of historical stability, they are also malleable [27]. People continually appropriate and restructure existing forms to serve new functions in light of shifting goals and expectations [27], opening the possibility that interaction designers can intentionally create transitional forms that maintain aspects of the source forms, while, at the same time, supporting novel activities (such as computer programming).

A final point is that cultural forms are culturally specific. Forms that make sense in one context are not recognized in other contexts, or are not recognized in quite the same way. Cultural forms might be more or less accessible to different members of the same group depending on factors such as age, gender, education, and individual experiences. For example, experience in a specific domain (such as computer programming) might change the meaning and utility of various forms [27]. For these reasons we thought it was important to test our prototype in diverse cultural contexts.

3.2 Stickerbook Design

Thinking about this project from the standpoint of cultural forms helped us to identify several possible design directions. The idea of using a stickerbook to introduce programming activities was immediately appealing because we thought that it provided a rich and recognizable form with advantageous practice-linked resources. Specifically, we hoped that the storybook form would promote parental involvement in structuring the activity. We also assumed that kids would be familiar with stickers and would know how to stick them to a sheet of paper. Another appealing aspect is that the materials involved are relatively inexpensive and lend themselves to mass production and distribution.

This project was challenging in that both the narrative structure and the supporting technology were untested and needed to be able to function in concert to create an engaging and enjoyable experience for parents and children. Based on Wyeth [34] and Horn et al.'s [16] work on programming curriculum for early elementary school children, we attempted to introduce a series of powerful ideas [2, 22] from computer programming and robotics through the storybook. Following [16] we selected programming activities to build on one another conceptually while remaining developmentally appropriate for children in our target age range (see Table 1).

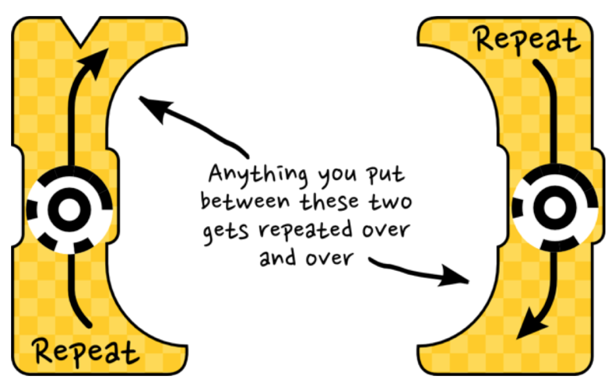

Figure 4. Begin and End Repeat stickers.

Table 1. The storybook activities introduce children to a series of powerful ideas from computer programming (see [16]).

Activity 1: Sequence of Actions (prompt: Use the stickers to help Roberto dance)
Children create a program consisting of a BEGIN, an END, and three simple actions stickers in between.

Activity 2: Infinite Loop (prompt: Use the stickers to make Roberto dance without stopping)
Children expand an activity 1 to include a repeat loop (Figure 4) that repeats forever.

Activity 3: Counting Loop (prompt: Use the stickers to make Roberto repeat his dance three times)
Children modify the program structure of activity 2 to repeat only three times in a row.

Activity 4: Sensor Input (prompt: Use the stickers to wake Roberto up when you tap on the screen)
Children create a program consisting of a simple sequence of actions that interact with smartphone sensors (e.g. tapping the screen).

Activity 5: Open-ended prompt (prompt: How do you think the story ends?)
For the last activity, children are invited to create any program they desire to conclude the storyline.

Working with a storybook illustrator we iteratively developed and tested several prototypes and storylines over the course of a year. Our current prototype follows the story of a lonely boy named Roberto (Omar in our Arabic translation) who travels across a city in search of new friends (Figure 2). Each encounter between Roberto and the characters in the story prompts a programming activity as shown in Figures 2 and 6. As with other tangible programming languages, the stickers themselves encode a physical syntax that indicates how they can be combined together on the page. For example, the BEGIN sticker has an outgoing notch but no incoming notch, while the END sticker has an incoming notch, but no outgoing notch (Figure 3). Likewise, the REPEAT stickers shown in Figure 4 have an angular indentation on the top to indicate the location of a parameter sticker. We tested several variations of sticker shapes before settling on those shown in Figures 3 and 4. The challenge was to find a shape that took up as little horizontal space on a page as possible while still allowing room for text, an icon, and a TopCode on each sticker. The sticker shapes also had to be easy for children to place on the page with reasonable accuracy.

Figure 5. The sticker programs control a digital version of Roberto that is animated on a smartphone or tablet computer.

Dashed sticker outlines on the pages of the book (see Figures 2 and 6) indicate the structure of the programs that can be created, as well as the types of stickers that can be used. There was a design tradeoff in terms of providing enough guidance for parents and children to learn how to create programs without getting frustrated while at the same time not being overly restrictive in terms of creative expression. In general we strove to keep the design as minimal as we could and to avoid textual instructions whenever possible. However, based on pilot testing, we found it necessary to include two pages of brief instructions at the beginning of the book to describe the process of creating and running programs. Finally, to revise programs, children can either peel the stickers off the page to reuse them, or they can stick a different programming statement directly on top of another statement.

3.3 Implementation

The programs that families create are acted out by a digital version of Roberto on the screen of a smart phone or tablet computer (Figure 5). To translate physical stickers into executable computer code, we adapted the technique of Horn et al.'s Tern programming system [16]. In particular, each sticker includes a TopCode computer vision fiducial that identifies both the type of sticker and its placement relative to other stickers on the page (Figures 3 and 4). To capture programs digitally, we developed an Android app that uses a mobile device's built-in camera to take a photograph of the page. The individual TopCodes are then decoded from the digital image and converted into assembly instructions. This assembly code is then fed into a runtime interpreter that controls an animated version of Roberto that appears on the screen of the device (Figure 5). The compile process takes two to three seconds depending on the device.

4. RESEARCH QUESTIONS

In evaluating our prototype, we were interested in two questions. First, was the storybook cultural form a good starting point for our design? In other words, was it effective in cueing parents to provide structure and support for their children in the programming activities? We were especially interested in how parental practices from storybook reading translated into computer programming activities.

Second, we developed our stickerbook prototype with the assumption that practices surrounding storybook reading would vary dramatically from household to household and region to region. Therefore, we were interested in the question: Are there cultural differences in the ways in which parents support their children? To address this research question, we conducted testing with English-speaking families in the United States Midwest and Arabic-speaking families in Riyadh, Saudi Arabia.

5. EVALUATION

To evaluate our prototype, we recruited caretaker-child dyads through fliers and word-of-mouth. The participants dyads read the storybook and completed the activities together. Sessions were held either at participant homes or at our campus laboratory.

Figure 6. Page from the Arabic translation of the storybook. In the translation, Roberto's name was changed to Omar (عمر). The direction of the computer programs was also reversed to right-to-left to be consistent with written Arabic.

5.1 Participants

Eight caretaker-child dyads participated in the study in the United States. There were 4 boys and 4 girls, all between the ages of 4 and 10 (average age 6.63, SD=2.0). All of the families spoke English during the study. Six dyads participated in the study in Saudi Arabia. There were 3 boys and 3 girls between the ages of 4 and 8 (average age 6.0, SD=1.41). All families spoke in Arabic during this study. For these families, we translated the storybook, stickers, and app to Arabic (Figure 6). We also reversed the direction in which programs were assembled (right-to-left rather than left-to-right) in order to be consistent with written Arabic. All families received a gift certificate worth around $15 USD.

5.2 Methods

After signing consent forms, we presented participants with the storybook, sticker sheets, and a mobile device. We then invited them to read the story and do the activities together. If the participants asked the researcher for help, we asked them to try to resolve the problem on their own. The researchers only intervened when a problem prevented the continuation of the activity. All of the sessions were video recorded, transcribed, and translated to English for analysis. The transcriptions included 2,798 lines spoken by adults. Informed by research on storybook reading [1, 4, 5, 6, 28], we iteratively developed a coding scheme focused on the parents' role in the sessions. We coded all of the sessions using the scheme shown in Table 2. Two researchers obtained 92.3% agreement on these codes based on 15% of the transcripts (Kappa = 0.664).

6. FINDINGS

6.1 Parental Support Activities

Our first research question involved understanding the ways in which parents structured the programming activities to support their children's learning. Five broad categories of parental activity emerged from our data (shown in Table 2). Technical support refers to identifying and helping to operate equipment such as the mobile device, its camera, the software, and the stickers (e.g. placing the stickers correctly on the page). Task support is more conceptual in nature and focuses on the hows and whys of computer programming. This includes drawing connections between programming concepts and children's knowledge and prior experiences; elaborating components of the programming task; and explaining how the programming system worked. Emotional support includes offering praise and encouragement; and confirming a child's decisions or actions. Finally, lesson-oriented activities involve quizzing children about the meaning of the stickers or the text as well as directly instructing them to perform certain actions.

Many of the parental support strategies for computational literacy seemed closely related to strategies for general language literacy, and it was often difficult to distinguish between the two. For example, the following excerpt comes from a four-year-old girl and her mother in the United States. The pair had just started their first programming activity in the book and the mother used the opportunity to help familiarize her daughter with the programming stickers.

Table 2. Coding scheme for parent support activities.

Lesson-Oriented Activities
• Giving direct instructions
• Quizzing children about the book, stickers, or programs
Language Literacy Support
• Helping child read and interpret the story
Technical Support
• Helping child with tablet and camera
• Helping child with stickers or identifying stickers
Task Support
• Elaborating on the steps of the programming task
• Describing programming syntax or semantics
Emotional Support
• Verbally acknowledging and encouraging children
Questions the Researcher
• Asking the researcher questions during the session

Mom: So what, what different things can he do in the dance?
Daughter: Uh, that one, and I mean. That one, and that one, and that one [referring to stickers].
Mom: What about these?
Daughter: Well actually, this one.
Mom: Which one is this? What's the word?
Daughter: Spin!
Mom: Spin. So what, if we use this sticker, what will he do?
Daughter: Uh, spin.
Mom: This one?
Daughter: Walk.
Mom: Walk.
Mom: [pointing other stickers in turn]
Daughter: Stand.
Daughter: Run.
Daughter: Spin [inaudible] ah ha ha!
Mom: That will be a fun one.

The mother begins this excerpt by elaborating on the programming prompt: "use the stickers to help Roberto dance". By asking her daughter what "different things can he do", she was orienting her daughter to the physical materials needed for the programming activity—in the video she had positioned the stickers in front of the storybook and was pointing to individual stickers in turn. Throughout the session, the mother positioned the various pieces of equipment for her daughter to notice and identify.

The mother appeared to take advantage of the first activity to not only familiarize her daughter with the range of possible programming stickers, but also to practice reading skills; the girl at age four was just able to read the words on the stickers. The mother pointed to each sticker in turn and waited for her daughter to say the word out loud, after which the mother repeated the word. And, by asking her daughter to predict the effect of stickers ("if we use this sticker, what will [Roberto] do?"), she assessed her daughter's understanding of the words on the stickers as well as the ways in which the system functioned to control the digital character.

At another level, the mother seemed to be emotionally framing the activity for her daughter by saying things like, "that will be a fun one". In other words, she was setting up the activity as something that would be fun to participate in.

Finally, the mother in this dyad (like many of the parents in our study) provided a range of technical support to her daughter. These included things like helping her daughter to peel stickers off the sheet, helping her hold and position the tablet computer when it was time to take pictures of the program, and identifying elements of the user interface (such as buttons on the screen) for her daughter to press. Throughout the session, the mother seemed to continually reassess her daughter's ability to manipulate elements of the system, allowing her to perform the tasks on her own when she was capable. Such scaffolding and fading of support was commonly cited in research on parents and children reading together [1, 4, 6].

6.1.1 Making Connections

While reading with children, many parents make connections between elements of the story (characters, illustrations, and objects) and the world of the child [1, 4, 6]. In our data, this type of extra-textual elaboration often carried over into the programming activities as well. For example, one father and his 8-year-old son were working on the second programming task together. The boy was a proficient reader, and he quickly read the text of the story out loud while the father watched and listened mostly in silence, mainly making comments or asking questions about the task between the pages of the storybook. As the boy completed the second activity, the father called attention to the repeat stickers.

Dad: [points to begin repeat and end repeat stickers] What, what does... What we're creating here is like on the DJ software that we use and you guys create loops.
Son: [adds stop sticker] Yup.
Dad: That's a loop. You know that's how we capture the start and the end. All right, do your thing. See if you can make it work.

Here the father attempts to draw a parallel between a programming control structure (a loop) and another aspect of the child's life that he knows his son has experienced.

6.1.2 Lesson-Oriented Activities

Some parents also seemed to use the activity as an opportunity to teach language and programming skills to their children. These types of interactions were characterized by frequent direct instructions and questions about the meaning of the text, images, and programming stickers. Parents would also often repeat their child's answers to questions.

6.2 Cultural Differences

Our second research question involved understanding differences in the stickerbook activity due to cultural differences between families in two distinct countries: United States and Saudi Arabia. Prior research comparing parent-child reading practices of Dutch, Turkish-Dutch, and Surinamese-Dutch families, found cultural differences in the ways in which parents supported their children during storybook reading sessions [4].

As we began to analyze our video, one obvious difference was the degree to which Saudi parents questioned the researcher during the sessions. Even though we instructed parents to try to figure out the activity on their own, Saudi parents asked the researcher an average of 21 questions per session compared to 4.13 questions per session from US parents (Figure 7). Typical questions involved clarifying the purpose of the activity and asking whether or not they were doing things correctly. This suggests that the Saudi parents interpreted the purpose of the study differently than US parents.

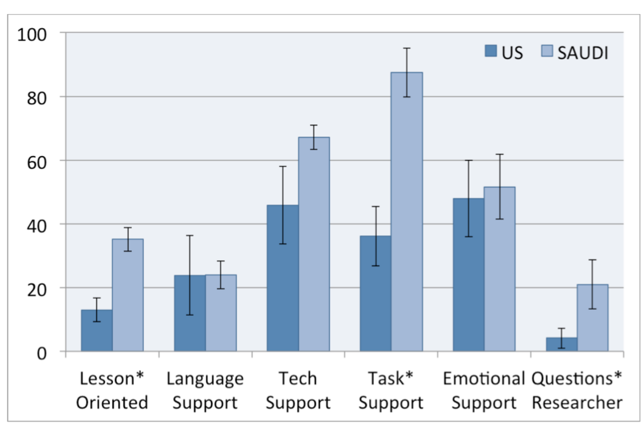

Figure 7. Instances of parental support in US and Saudi families. Significant differences are denoted with (*) ($p < 0.05$).

This difference in interpretation seemed to carry over into the interactions between parents and children as well. Overall Saudi parents made much more frequent use of direct instructions and assistance with the stickers than US parents (see Figure 7). They also provided more frequent explanations of the programming tasks and system. From these data, it appears that the Saudi parents saw the activity as an opportunity to offer direct instruction to their children, both in terms of general language literacy and computational literacy. For example, this excerpt came from a Saudi mother reading with her son (age 8):

Mom: Tap... Forever [reading]. Can we use these now? [question directed to researcher]
Researcher: What do you think?
Mom: [pasting sticker] ...gets repeated over and over
Son: Run
Mom: This is jump here [correcting son]
Kid: Jump, sleep... so he could get some rest.
Mom: Okay, what next?
Kid: Sleep, so he could get some rest.
Mom: Sleep?!
Kid: Yes, to get rest!
Mom: Umm, no. Jump and then directly sleep? I don't think it is appropriate.
Kid: He plays a lot
Mom: Yes [laughs]

The US parents also treated the stickerbook as an opportunity for learning, but the activity seemed more child-directed. For example, US parents asked almost twice as many quiz-like questions as Saudi parents (not significant), but they also provided less physical assistance to children while at the same time offering slightly more emotional support (also not significant). On average US parents also spoke less than their Saudi counterparts. There were 204 utterances per session average for US parents (SD=115) compared to 309 utterances for Saudi parents (SD=33.6); $t(12)=2.14$, $p=0.054$. The average session length for Saudi families was 35.12 minutes (SD=4.4) while the average session length for US familes was 30.74 minutes (SD=8.86). The difference was not significant.

These results should be interpreted with caution. While the differences were significant in many cases, our sample was small, and other factors beyond culture and language might have contributed to these results. One important factor could have been that the US families were recruited from a University campus, while the Saudi families were not.

7. DISCUSSION

At one level this paper explores new ways to support children's early computational literacy. We believe that this is important not only to develop the next generation of scientists and engineers, whose professions are indisputably more computational than ever before, but also to support a computationally literate citizenry (teachers, doctors, lawyers, artists, activists) in an increasingly computationally-oriented world [2, 8, 22, 25, 33].

At another level, this paper explores the idea of designing through cultural forms as a way to invoke valuable cognitive, social, and emotional resources. In this case we embedded computational literacy activities within a children's storybook in a deliberate effort to not only encourage parental involvement but also to suggest effective ways for them to be involved. Because we work from recognizable cultural forms, we hope to facilitate interactions between parents and children that might not otherwise occur. And, in this case, our role as designers is to make evident the connection between early language literacy and early computational literacy.

Here the legibility of the cultural form is critical. Imagine that the instead of a paper storybook, we had instead created an activity that existed entirely on a tablet computer. This would have made the creation of programs easier, but might have also obscured the underlying cultural form. Plausibly, the tablet computer itself, would become the most salient aspect of the activity, a device that can be a video game, an email client, a music player, a camera, and so on. The social activity structures surrounding the tablet computer are correspondingly diverse, but this flexibility could have a downside. As parents and kids engage with the device, there is a period of uncertainty and orientation that must take place before the familiar form of the storybook begins to surface. Powering on the device, fumbling through homes screens, and finding the right icon to launch the app. There is also a looming possibility that the activity will be interrupted when a child accidentally presses the home button and dissolves the storybook world. Finally, there is a period of learning that must take place once the book/app is launched. This is because the use of an e-book implies a sort of metaphorical gulf that parents and children must bridge. In other words, a mapping between the experience of reading a physical book and interacting with an e-book must be constructed and then mutually agreed upon by the parent and child. "Look, this screen is just like the page of a book, and sliding a finger is like turning the page."

Our results highlight some of the opportunities and challenges of working with paper books. In cases where parents or caregivers were less involved, children struggled to make sense of the activity on their own. On the other hand, when parents were more actively involved, we observed many instances of learning interactions in which parents scaffolded their children's understanding of the programming activities. And, while we observed differences between US and Saudi parents in the ways in which they interpreted and structured the stickerbook activities for their children, both supported what seemed to be valuable learning interactions.

8. LIMITATIONS AND FUTURE WORK

One limitation of this work is that the sticker/computer vision mechanism might be more difficult to use than a purely graphical programming system. Another approach might be to offer the programming activities entirely on the screen of the mobile device with the storybook as a companion element. Or we could create a hybrid environment [16] in which kids could program either with stickers or on the screen. These are directions we would like to explore in future research.

A second limitation is that despite recruiting participants in two countries and two languages, our sample was still narrow and relatively affluent. In the future, we might test with a broader range of families even within one country to capture a more diverse sample. We would also like to include an assessment of learning outcomes to provide quantitative data on the effectiveness of this approach in fostering computational literacy.

9. CONCLUSION

In this paper we presented a computational literacy stickerbook. Our goal is to create an engaging informal learning experience that introduces powerful ideas from computer programming in a somewhat structured format. To accomplish this, we adopted the cultural form of a children's storybook. The use of the narrative structure of a storybook allowed us to arrange the programming activities in a linear sequence of increasing complexity. We also expected that storybooks would engage parents in helping to structure and support their children's learning. To test these ideas, we conducted an evaluation with 14 families from the United States and Saudi Arabia. Our findings suggest that parents and children engage in a variety of literacy-related activities while reading the book and creating programs. Many storybook reading practices seemed to carry over into the programming activities as well.

10. ACKNOWLEDGMENTS

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