From Storytelling to StoryMaking:  
Children Creating Stories with Tangible Computational Media

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Abstract  

Storytelling and making are two of the oldest forms of self-expression. Through stories we give meaning to our everyday experiences making sense of our world. By making physical objects, we can create tangible representations of our ideas that we can share with others. This thesis investigates how to introduce children and educators to StoryMaking, a process that cultivates creative learning by combining new forms of storytelling and new forms of making with technology.  

In this research, I highlight the process of StoryMaking, exploring ways for children to make physical representations of their personal stories using Tangible Computational Media (TCM) – a medium that enables them to design and create physical objects with interactive and dynamic behaviors.  

Through workshops I observed children's StoryMaking explorations with three forms of TCM: paper electronics, programmable projections, and sewable circuits. Based on my observations and the analysis of the artifacts, I share how children represented their personal experiences artistically, electronically, and computationally.  

Through case studies, I reflect on my experiences facilitating these StoryMaking workshops. Based on these experiences, I describe ten design practices that can help other educators design and facilitate StoryMaking experiences in their learning settings.  

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1.1 From Storytelling to StoryMaking

When I was young, the term Storytelling meant narrating a story that I already knew. Stories that I told were somebody else’s stories that had been told and retold multiple times. I told stories that had been taught to me by my family, my teachers, and my friends. The ones that had morals and values, the ones that had protagonists, antagonists, and conflicts. When I grew a little older, I was telling stories that I learnt from literature and media with a little more twist, a little more complexity, and a little more drama. I kept memorizing and performing stories until one day someone asked me, “So what’s your story?”

I wondered what did they mean by “your story.” Was it the story about my personal experiences or was it the story that I created? Probably both. At that time, I didn’t think I had a story about myself to tell. I was taught how to tell (narrate) stories but I had no knowledge about how to make (construct) a story, especially one based on myself.

This motivated me to learn the art of making stories that are inspired from personal experiences. In order to understand this, I started looking at the process of storytelling and the process of making. I wondered if there was any connection between these two and if they could influence each other. I couldn’t help but think about my mother, who is a clothing maker with a real flair for storytelling. The way she sewed pieces of fabrics together to make a finished garment, she also connected pieces of her experiences together to tell her story.

Growing up, I recognized myself as a maker exploring different forms of arts and crafts. Textile and fashion school introduced me to various kinds of traditional Indian textile crafts such as Kalamkari, Sujani embroidery and Baluchari, which showed me how artists painted, embroidered and weaved stories on fabric. In order to gain practical skills, I made some personalised projects exploring these arts. In the process, I found myself intuitively learning
artistic and science concepts such as aesthetic composition, color theory, weaving, mathematics, proportion/scale, and textile chemistry and properties. Through this experience, I recognized a connection between the process of making and the process of learning.

I went on to study Design in Education at Srishti Institute of Art Design and Technology. The program introduced me to unique approaches to learning through making. In particular, the program focused on helping children develop a strong sense of self by providing them with opportunities to bring personal meaning to their creations through stories.

I then approached self-exploration through the lens of personal narrative, and thus became interested in exploring the synergy between the wonderful art of storytelling and the powerful process of making. At the MIT Media Lab, I became aware of new interactive technologies that could enhance experiences of storytelling, making, and learning. I became motivated to develop rich and meaningful learning pathways for children by engaging them in making experiences, introducing new technologies as narrative mediums for self-expression.

This effort to weave together storytelling, making, and learning with new technologies builds on several strands of recent research and development. Many artists and designers are exploring new media technologies for representing stories and experiences in new ways, adding dynamic interactions to their creations. But few children have these opportunities. While more schools and community centers are opening maker spaces that provide children with hands-on experiences building with technology, these initiatives typically do not support narrative exploration and deeper artistic expression. How can we provide children with opportunities to express themselves creatively through a combination of making and stories?

This thesis is dedicated to exploring ways for children to make physical representations of their personal stories. I introduce StoryMaking, a process that cultivates creative learning by combining new forms of storytelling and new forms of making with technology. I highlight this process by sharing participatory maker experiences for children with Tangible Computational Media (TCM) – a medium that makes it possible to design and create physical objects with interactive and dynamic behaviors. I developed activities and
workshops for introducing children to TCM as a way to connect, express, and bring to life personal narratives. The focus is on engaging children in constructing stories through meaningful artistic explorations, empowering them to express and present their experiences in new ways with technology.

1.2 The Value of Storytelling + Making

Storytelling and making provide two different forms of creative expression. Storytelling provides opportunities to express the self; making provides opportunities to represent the world. Independently they each allow us to reflect, refine, and represent our experiences. When we tell a story, we express our experiences by creating a narrative representation; when we make things, we express our observations and experiences by creating a physical representation.

When we tell a story, we engage with ideas through the story. When we make the story tangible and concrete by creating a physical representation of it, it gives us another way of thinking about those ideas. For instance, when someone tells a story about Joseph and His Coat of Many Colors, they communicate and explore Joseph's relationship with his father, his brothers, and his coat. If the storyteller also makes an actual coat of many colors, the physical representation provides another opportunity to communicate and interpret the meaning of the coat of many colors.

Creating multiple representations of an idea fosters deeper understanding and learning. When we construct representations of ideas that we are learning in multiple ways, we make deeper connections to those ideas. As Marvin Minsky wrote describing the importance of multiple forms of representation: "If you 'understand' something in only one way, then you scarcely understand it at all.” (Minsky, 2006, p. 6). Combining storytelling with making can provide multiple ways of thinking about one's ideas. StoryMaking engages children in creating multiple representations of their observations and integrating them into coherent narrative and physical form, enabling them to make deeper and personally meaningful connections with the ideas they are exploring.
Through StoryMaking with Tangible Computational Media, children become engaged in using both storytelling ideas and computational ideas to represent their experiences. Storytelling and computation share some common elements. Narrative thinking engages us in telling stories that have a flow, suggesting sequences of events that progress through time (Staker, 2015). While making stories, we engage in the process of creating this flow of events, connecting them with one another and stating the cause and effect. Sometimes, there are separate flows or streams (as Straker calls it), which include situations that are parallel, different events happening at the same time.

Many stories have these dynamic elements of flow (sequences of actions), significant events (one action causing action to happen), and parallelism (sequences of actions happening at the same time). Computational thinking also involves these concepts of flow, events, and parallelism (Brennan & Resnick, 2012). Storytelling or making may not explicitly highlight these concepts, but StoryMaking with tangible computational media can focus children on investigating and bringing together dynamic ideas about flow, triggering events, and parallelism. By engaging with these ideas in multiple ways (through both storytelling and making with TCM), children can develop a deeper understanding for these ideas.

I feel that storytelling and making also have a mutual relationship where each process inspires engagement with the other. Personal experiences can provide creative inspiration for developing new hands-on skills; and making can provide stimulus to observe, reflect, and connect with personal experiences. Stories can serve as a starting point to explore new ideas guiding the physical representation. Hands-on exploration with new materials can help to construct and refine our story, giving it a physical form that communicates personal meaning.

StoryMaking can provide multiple pathways for children to develop new ideas. Children who are interested in stories can use StoryMaking as a way into learning about constructing with new materials and engaging with computational ideas. Children who are interested in hands-on making and new media can use StoryMaking as a pathway into personal expression through stories. These pathways will enable children to construct stories about themselves in their heads while constructing things with their hands and integrate them to express what they find meaningful in their world.
1.3 Thesis Overview

In this thesis, I describe the process of engaging youth in creating stories using three forms of tangible computational media: paper electronics, programmable projections, and sewable circuits. I share examples and experiences from a series of workshops based on this approach for youth in diverse environments. Participants in these workshops designed artifacts—such as story quilts, interactive storybooks, and e-textile murals—to depict stories inspired from their personal experiences.

Through observations of participants' interaction with the medium and analyzing their artifacts, I have seen how stories bring personal meaning to creation that reflects young people's senses, feelings, perceptions of the world, and what matters to them. I have found that this approach to story-making is appealing to children and can contribute to extending their creative potential in deep and meaningful ways. For example, a girl in Bangalore created an interactive storybook using paper electronics to tell a story about arguments over access to water in her village and how they could be resolved.

Finally, I reflect on my experiences facilitating StoryMaking experiences through case studies and share my reflections and insights with other educators by articulating a set of ten design practices for facilitating StoryMaking. I hope these design practices will help educators for designing and facilitating StoryMaking experiences with children, empowering them to express and present their experiences in new ways with technology.
In this chapter, I highlight some traditional approaches to Storytelling and Making, and review existing tools and resources that support children’s storytelling with new technologies and making with new technologies. I then describe Tangible Computational Media tools. Next, I share some artists’ work exploring TCM for self-expression. Finally, I share artistic and computational thinking framework that I hope to highlight in the design of StoryMaking activities, workshops, and practices.

2.1 Storytelling and Making

Narratives shape our experience of the world (Bruner, 2003). Through stories we give meaning to our experiences. Storytelling empowers the transformation of our intuition into more explicit understanding, allowing us to make sense of the world and express ourselves. Making is the tangible representation of our ideas, enabling us to bring our imagination into the real world through physical objects. Hands-on making explorations create opportunities for people to engage with the world and create connections with each other (Gauntlett, 2011).

Arts, crafts, and storytelling are our oldest forms of understanding (Weber, 2001). Some of the ancient traditional forms of storytelling such as quilts and shadow puppetry include creating physical artifacts to communicate stories. Traditionally, stories may have been used to entertain or to educate audiences. In this thesis, I am looking at stories as a means of nurturing deeper self connections to learning and bringing personal meaning to what individuals create. With children I am building on traditional story-based crafts such as story quilts, pop-up books, and textile murals.
2.2 Constructing Narratives

I am creating participatory experiences for children where they are consciously engaged in personal narrative explorations by designing tangible interactive artifacts. This work builds on theories in two different domains. I am building on approaches from Seymour Papert’s theory of Constructionism (Papert, 1993). Constructionism holds that children learn best when they are engaged in constructing personally meaningful artifacts. My thesis work also builds on Cynthia Kurtz’s (2014) work on Participatory Narrative Inquiry. Participatory Narrative Inquiry focuses on involving groups of people in engaging with stories of personal experience in order to make sense of complex situations for better decision making. Many artists have previously applied this approach through art forms such as participatory story quilts, community murals, and devised theatre.

2.3 Tangible Computational Media

Advances in technology have introduced new forms of Tangible Computational Media that are changing the ways and the types of things people can create. By the term Tangible Computational Media, I refer to the tools that allow us to create physical objects that have computational capabilities, enabling us to construct new interactions and behaviors. There
are now commercially available and accessible TCM tools such as: the LilyPad Arduino, a construction kit to build soft, wearable computers (Buechley & Eisenberg, 2008); Circuit Stickers, tiny peel-and-stick circuit boards to build interactive electronic projects (Qi, 2014); and Tiny Programmer, a circuit board to program ATtiny45 and ATtiny85 microcontroller (Mellis, Jacoby, Buechley, Perner-Wilson, & Qi, 2013). Such computationally enhanced construction kits (Eisenberg et. al, 2002) are opening up new possibilities to make things in innovative ways. They also have potential to create new forms of engagement by bringing dynamic forms of interactions to traditional modes of storytelling.

Figure 2. Examples of TCM tools (from left): LilyPad Arduino (Buechley, 2008), Circuit Stickers, (Qi, 2014) and Tiny AVR Programmer (Mellis, 2013).

Figure 3. Electronic popables by Jie Qi (left), Theatre Book MacBeth by Davy Kristin McGuire (right)

Artists and designers have been incorporating new TCM materials and techniques in their practice to represent their experiences in unique ways. Jie Qi’s (2010) project Electronic

2.4 Children Storytelling with New Technologies

A few research projects have looked specifically at the technologies especially for youth to support storytelling. Scratch (Resnick et al., 2009) is a free programming language and online community where you can create your own interactive stories, games, and animations. Narraratium (Novy et al., 2013) is an immersive storytelling environment to augment creative play using texture, color, and image. Narrative Construction Kits (Bers, 1999) aim to help children and teenagers explore identity and values as dynamic complex constructions. StoryMat (Ryokai & Cassell, 1999) offers a child-driven story listening space by recording and recalling children's narrating voices, and the movements they make with their stuffed animals on a colorful story-evoking quilt. StoryScape (Eckhardt, Goodwin, & Picard, 2013) is an inclusive creative learning platform that allows users to create stories in order to facilitate constructionist participatory learning.

2.5 Support Materials for Facilitating Making with New Technologies

Another set of research projects have created support materials for facilitating making with new creative technologies for helping children design their interactive projects. These include Leah Buechley and Kanjun Qiu's Sew Electric book (2013), which captures a set of LilyPad Arduino tutorials bringing together craft, electronics, and programming. Another electronic textiles guide, Emily Lovell's Soft Circuits curriculum workshop facilitation guide (2011), provides instructional support materials specifically to educators to facilitate e-textile activities in settings such as science museums, after-school programs, or summer camps. For paper electronics, Jie Qi's Circuit Sticker Sketchbook (2014) introduces examples through circuit templates and open-ended template activities. Finally, the Start Making! (in press)
guide, my own project in collaboration with Danielle Martin, introduces project-based making to facilitators using a wide variety of TCM.

Figure 4: Support materials for making with new technologies (from left): Start Making! @ clubhouses session guide, Sew Electric book, and Soft Circuits facilitator’s guide

2.6 Art Synectics and Computational Thinking

StoryMaking draws inspiration from Art Synectics (Roukes, 1982), a book that suggests ways to introduce creative concepts in art through making projects. I applied artistic practices suggested in Art Synectics to engage children in representing their personal experiences using TCM. These include concepts such as logical analogies and affective analogies. Logical analogies refers to choosing images that share similarities in design, structure, or function. Affective analogies refer to images that share emotional resemblances.

I also designed experiences for children using TCM to create pathways into computational thinking. I applied some of the computational thinking approaches described by Karen Brennan and Mitch Resnick (2012) in the context of StoryMaking. These approaches from their computational thinking framework include computational concepts (such as sequences and parallelism), computational practices (such as being iterative, abstracting, and modularizing), and computational perspectives (such as expressing, connecting, and questioning).
Chapter 3
Research Process

In this chapter I describe the overall research methodology and the goals of my investigation. A detailed description of the workshops and their results are discussed in further detail in chapters 4, 5 and 6.

3.1 Research Questions

In this research, I investigated three fundamental questions:

- What types of personal stories can children create using the new media of Tangible Computational Media?
- What do they learn through this process of StoryMaking?
- How can we support educators to design and facilitate similar experiences engaging children in constructing narratives using TCM?

Through my explorations, I sought to create an environment for children to foster an intuitive sense of tinkering with TCM while making connections to their personal experiences. I was trying to understand how children represent their world through the storied artifacts that they create. I wanted to share this process with educators so that they could provide new pathways for children to understand their world, reflect on their experiences, and express themselves using TCM.

3.2 Workshops Overview

To achieve this goal, I iteratively designed StoryMaking workshops for children and educators to document and understand the ways in which they can express and represent their personal stories using TCM. I designed and facilitated workshops introducing StoryMaking to children and educators from different communities using TCM as a medium for creating stories. These media were chosen based on material simplicity, diversity, aesthetic
appeal, and familiarity to participants. The idea was to enable participants to express themselves with familiar materials and techniques while also enabling them with the interactive powers of computational media. Participants in these workshops designed and created three types of tangible artifacts each using different forms of TCM:

(1) **Paper Electronics**: Paper electronics is the construction of circuits on paper using conductive foils, tapes, or inks to make connections between electronic components such as lights, sensors, and programmable microcontrollers. Creators can express themselves by creating circuit patterns with the conductive materials and by decorating their circuits with traditional paper craft media. In the paper electronics workshops, children shared their personal experiences by combining electronics with paper craft techniques. They made artifacts such as interactive storybooks, story frames, and story-based installations to depict their personal stories.

(2) **Programmable Projections**: Programmable projections are interactive Scratch programs projected onto three-dimensional paper sculptures to create dynamic scenes on static forms. Using programmable projects, participants integrated paper pop-up art with Scratch programming, connecting computation to the physical world. The children experimented with physical-digital interactions on paper, such as turning the page to trigger an animation.

(3) **Sewable Circuits**: Sewable circuits are circuits made on textiles using conductive threads and fabrics to create connections between electronic components. Using sewable circuits, participants learned to create stories combining textile arts with electronic devices, including a programmable MP3 player. They created textile projects representing their stories using lights and audio.

In each workshop, I introduced children to a particular form of TCM combined with a traditional craft-based mode of storytelling. I used commercially available and accessible TCM tools and materials along with a selection of craft and construction supplies. Some of the workshops were held in informal learning environments and others were in schools. The following table lists the different formats, types of media, the location, who participated, and the length of the workshops.
### Workshop

**Interactive Storybooks**
- **Tangible Computational Media**: Paper Electronics
- **Location**: Drishya, Bangalore, India (Jun, 2014)
- **Participants**: 10 Children, 10-14 years
- **Length**: 10 sessions, 4-5 hours

**Paper Theater with Digital Projections using Scratch**
- **Tangible Computational Media**: Programmable Projections
- **Location**: Drishya, Bangalore, India (Jul, 2014)
- **Participants**: 15 Children, 9-12 years
- **Length**: 7 sessions, 4-5 hours

**Textile Narratives**
- **Tangible Computational Media**: Sewable Circuits
- **Location**: Computer Clubhouse Teen Summit, Boston, MA (Jul-Aug, 2014)
- **Participants**: 16 Teens, 14-17 years
- **Length**: 4 sessions, 3-5 hours

**Circuit as Crayons**
- **Tangible Computational Media**: Paper Electronics
- **Location**: Woodwhistlers School, Dharamshala, India (Oct, 2014)
- **Participants**: 15 Children, 6-8 years
- **Length**: 2 hours

**Creativity Mornings—Electronic Arts**
- **Tangible Computational Media**: Paper Electronics
- **Location**: Acera School, Winchester, MA (Oct 2014-Apr 2015)
- **Participants**: 25 Children, 7-10 years
- **Length**: Multiple sessions, 45 minutes

**Creative Learning**
- **Tangible Computational Media**: Paper Electronics
- **Location**: MIT Media Lab (Mar, 2015)
- **Participants**: 16 Adult Facilitators
- **Length**: 2 hours

**Textile Narratives**
- **Tangible Computational Media**: Sewable Circuits
- **Location**: Annual computer Clubhouse Conference (Apr 2015)
- **Participants**: 4 Adult Facilitators
- **Length**: 5 hours

The first three workshops were held in informal learning centers. These were progressive and immersive workshops series lasting between 5 to 10 days, with 3 to 5 hours per session. These workshops allowed me to gain an in depth understanding of how children engage with different forms of TCM to create personal stories, their representation styles, and the learning outcomes.
Based on these experiences, I revised some of the activities and designed short independent workshop sessions from 45 minutes to 2 hours. I facilitated these sessions in K-12 schools introducing specific StoryMaking techniques and skills that could be potentially adapted as part of the school curriculum or after-school activities.

The final set of workshops were targeted towards educators as participants where I engaged them in the StoryMaking process, demonstrating my design practices. I aimed to seek their feedback on StoryMaking process: whether they would like to adopt StoryMaking approaches and how they would apply them in their teaching practices. I hoped to understand ways to support them in facilitating these activities.

3.3 Methodology

My study was exploratory and process-centered, with a focus on participants' engagement with different kinds of TCM and their learnings. The goal was to understand the aspects of creative learning environments that can support children to design novel representations of their stories using new programmable technologies. My research methodology involved activity-based ethnography or ethnographic action research (Gauntlett, 2007) where I engaged participants in different activities and observed them in the process of doing those activities. I also did artifact-based analysis where I documented and analyzed the products that the participants made in the workshops. During the workshop sessions, I facilitated and documented reflection circles where participants shared what they were creating and learning.
Chapter 4

Paper Electronics

In this chapter, I describe the first Paper Electronics workshop series that helped me crystallize and formulate the core StoryMaking concepts. I then share a case study describing the workshop experiences and learnings of a 12 year old girl who created a story using Paper Electronics to highlight water issues in her community. I conclude with my reflection and analysis of the workshop series.

4.1 Workshop: Interactive Storybooks

In this 10-day workshop, the participants explored paper electronics to make interactive storybooks. The workshop helped me to understand children’s interaction with paper electronics and how the process of story creation by crafting circuits on paper can influence creative learning.

I led this workshop series as part of a summer camp run by Drishya Kalika Kendra, a set of a progressive non-school learning centers located in Bangalore, India. Drishya offers innovative education for children living in urban slums. Drishya has unique pedagogical processes and tools designed by Project Vision, a research collective at Srishti School of Art Design and Technology in Bangalore, India. Project Vision aims to create sustainable livelihoods by empowering individuals through creating flows of knowledge across many levels: physical, emotional, cognitive, and psychological.

Drishya allows opportunities for artistic interventions in the form of summer camps. The camps are intensive two-week workshops where multiple artists come and become part of the learning community exchanging skills and perspectives with children and facilitators in order to co-build knowledge structures in the form of artifacts and performances. Children sign up for different camps and work on either independent or collaborative projects based on the structure of each camp. I had the opportunity to be part of the Drishya Summer
Camp and started facilitating workshops involving crafting stories with paper circuits. Two Drishya facilitators and one Project Vision member provided assistance in facilitation. Most of the children in the workshop spoke Kannada, the regional language that I do not speak. I communicated in Hindi and English, as a few of the children understood those languages. Drishya facilitators helped me translate. I had daily meetings with facilitating team where we shared our observations and findings.

A total of 10 children, ages 11 to 14 years, participated in this workshop series, six girls and four boys. As part of Drishya, these children had experience in storytelling, drawing, and craft. Three of them, two girls and one boy, who were the oldest in the group had some experience with making circuits but had little opportunity to continue making electronic projects. The remaining seven children has no prior experience in making circuits. Some of the children shared that they wanted to play with lights, some said that they wanted to make things turn on and off.

The overall theme for the workshop series was creating ‘Narratives about Self’, with a focus on creating interactive story books capturing experiences related to themselves and the world around them, including their friends, their families, and their communities. I suggested that the children make interactive storybooks stating the story of real-life events that they witnessed or experienced. I designed activities that introduced techniques related to paper craft, technology, and story creation. The goal was to facilitate a process that allows each child to acquire new skills and simultaneously make connections to their personal lives.

This workshop series consisted of ten sessions over the course of 12 days. Each session lasted for about 5 hours (with breaks for food). Children were also allowed to take other short breaks when they felt like it. The children initially made basic electrical circuits and moved on to creating interactive storybooks with multiple circuits, microcontrollers and sensors. In the sessions, I introduced electronic materials and technique as well as the craft materials and technique. As part of the daily practice, we allotted time for reflection and sharing. We called it ‘Opening Circle’ and ‘Closing Circle’ where the children engaged in discussion around these questions at the start and the end of each session. In the process I closely observed and documented their everyday engagement with the medium and their
creative process. I asked pupils to also share their ideas and learnings in writing. I gave the children writing prompts everyday asking them to reflect on their experiences.

In the first session I encouraged everyone to make a personal journal out of recycled cardboard, blank paper, and decorative paper. These were accordion books in which the children documented their project ideas, learnings, and other reflections. The journals also served as their portfolio where the children archived their work and tracked their progress. The journals also provided a way to document their understanding and feedback on the process.

In the first session I introduced making ‘Light Up Self Portraits’ using simple circuits made using a 3V battery, a light bulb, and conductive tape. I suggested that they represent their superpower (a personal strength) using LED lights. I did not give them circuit templates but instead showed them an example of my own self-portrait created using circuits. In my self-portrait, I represented my superpower of acute observation by placing LEDs aligned with the eyes in my sketch. In about 20 minutes, the children grasped the technique of creating the basic circuit and made their paper light-up self-portraits. Some struggled initially to make the light glow and were frustrated but other children helped them troubleshoot. Through this activity, I intended to scaffold how children could use lights to give personal meaning to their drawings.

Circuits became a new mode to represent an aspect of themselves that they valued. One participant created a glowing thought bubble with a book to highlight her power of willingness to learn, another participant placed the light on the head to represent his power
of knowledge (Figure 5). One girl was inspired by my drawing and made light-up eyes sharing her ability to see beyond and see what others generally do not see. The children were not only learning to create electrical connections to make the light bulb glow but also integrating their circuit creations to creatively express their superpower.

In the second session, I started doing an association exercise in which I gave the children two objects: one electronic and the other craft related. I asked them to imagine a conversation between those two objects (Figure 6). For example “What does an LED light have to say to a pencil?” This allowed the children to observe, analyze, and articulate the structure and behavior of different electronic materials and understand their artistic potential.

Figure 6. Association exercise: Two participants sharing the dialogue that they imagined between an LED light and a pencil.

In the afternoon session, I introduced how to make more complex circuits, including creating parallel circuits, making switches, and learning to solder. First, I shared some sample circuits with multiple lights and switches that used AND/OR logic. This allowed the
children to see how they could press two switches at the same time to turn one light on or use multiple switches in sequence to turn different lights on. I asked the children to represent a scene from their favorite place using multiple lights. I encouraged them to identify the dynamic elements of the scene and depict it using lights and switches. The children made interactive circuit drawings of scenes such as parks near their house, their dad’s village, their grandmother’s house, etc. Some of them made circuit drawings of inspirational objects, such as the sun, a guitar, and a flower. Some artifacts also included drawings of places they wished to visit, such as rivers and mountains. One 12-year-old boy made an interactive drawing with lights and multiple switches to make the lights turn on and off in sequence. He represented a river using blue lights. As the viewer slides their fingers over the drawing, they see a beautiful visual with light animation highlighting the flow of water in a very subtle yet magical way (Figure 7).

Figure 7. Interactive drawing representing a river made by 12 year old boy. Participant represented the flow of water using multiple blue LED lights and switches made with conductive tape.

Children were also envisioning the ways they could bring other kinds of interactions to their drawings. A 13-year-old girl drew of a scene from her village in which she used blue lights arranged in parallel circuit to show raindrops. She used a switch to turn on all the lights in her drawing at once (Figure 8). She shared with her peers that she wanted to show the rain falling from the cloud and wished that all the lights did not turn on at once but in different patterns instead.
In the third session, I introduced an activity where the children empathically projected themselves as other living beings. I asked them to make an emotion map. To create an emotion map, the children imagined themselves as any character or object of their choice, such as a tree, a flower, or a snake. They then made a drawing of their imaginary subjects and annotated their drawings with the text that described their feelings as the characters.

I later gave another task suggesting they embed a circuit in their drawings using a buzzer, a 3V battery, conductive tape, and a piece of velostat - a resistive paper that can be used as a pressure sensor. The children initially found this activity a bit challenging and needed some scaffolding. They could not associate the emotions with a circuit that makes sound. So I demonstrated my own process of adding the circuit to my emotion map and discussed with them how we could represent feelings using a buzzer and a pressure sensor. This helped them to use copper tape and other electronic parts to draw their own circuits (Figure 9).

I also introduced paper craft techniques such as quilling, paper appliqué, and paper weaving. At this stage, the children felt a little more comfortable with using electronic material as art materials. They had ideas about additional electronic materials that they wished they could have, such as brown lights, or a switch that gets triggered by adding water drops, or by sunlight.

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1 This activity is adapted from the book, Art Synectics (Roukes, 1984)
Figure 9. Emotion maps created by the children integrating circuits with a buzzer, battery, conductive tape, and pressure sensor

The fourth session was more technique focused. The children worked on finishing their prior projects, troubleshooting some electrical connections, and adding new components. I introduced how to use a multimeter to check electrical connections. Some of the children became experienced with using the soldering iron and started mentoring younger students on the technique. In the reflection circle they said that they enjoyed the soldering process and felt accomplished as they were doing something serious. They also shared that they wished to learn more advanced tools.

In the later half of the session, I showed the children the programmable Atmel ATtiny45/85 microcontroller. Without explaining the chip or its applications, I asked them to look closely at the chip and guess its purpose. They sketched and rendered drawings of ATTiny45/85 chip, highlighting its intricate details, including each pin and marks on the chip (Figure 10). It was the first time that the children held and closely observed a tiny electronic chip. Most of them thought that it was a chip people use to make computers, some thought that it was a memory chip for cell phones. By closely observing and sketching the chip, they discovered that the chip has four metal pins on either sides and a tiny circle marked at the corner. They also compared their drawings to find out that some children received a chip with a different number but the letters were same. They started questioning what those number meant. I also encouraged them to keep a note of all the questions about the tiny chip next to their drawings. Before telling them what the chip does, I wanted them to question and speculate the possibilities of using this chip or any new electronic material.
I then gave a brief overview of the ATtiny chip and microcontrollers in general. I also demonstrated the steps to program the chip using a Tiny Programmer a board that plugs into the USB port of a computer and loads compiled programs from the computer onto an ATtiny45 or ATtiny85 microcontroller, without the need for any additional connections or components (Mellis et al., 2013). I then programmed all the chips with the Touch code, created by David Mellis as part of his tutorial (http://highlowtech.org/?p=1653) to create a microcontroller circuit that adds capacitive sensing to the ATtiny 85 that makes the attached LED lights turn on, fade in/fade out and toggle while the user is touching the input pin. Later the children referred to a template showing an example circuit drawing (Figure 11) and made their own circuit in pairs. The children were given the freedom to modify the example circuit. This circuit was very different from the other circuits that they had been making due to the intricate structure of the chip. The children were pretty focused during the task and with some help, everyone managed to get their circuits working. Everybody’s circuit drawings looked very similar and had little variations (Figure 12) as almost everyone redrew the example circuit. After they were done, the children felt their goal was accomplished but felt very tired and did not want to continue further. We called the day off early.

In the fifth session, we shifted the focus back to storytelling and the children recrafted the circuit with a ATtiny 85 chip with Touch code, giving it a personal meaning. We did a neighborhood mapping exercise, where the children drew a map on paper locating things in
the range of 1 km from their houses. They then identified and elaborated on one scene that intrigued them the most. Later they crafted a circuit with a ATtiny microcontroller programmed with the touch code and designed interactive visuals with touch input that triggered different light behaviors such as fade, blink, toggle, etc.

Figure 11. A participant drawing a circuit referring to a template showing a circuit with a ATtiny 85/45 chip programmed with the Touch Code.

Figure 12. Circuits made by the children by referring to the example template.
This task was complex and needed a lot more scaffolding so I suggested a defined process. Rather than adding something to the pre-made circuit, I encouraged them to identify the parts of their drawing where they wanted to show interaction. Children made a card with a drawing of their neighborhood scene on the front. They later marked the positions to place the lights on a separate sheet of paper aligned with their drawings. Next, they marked the area where they wanted touch interaction. Using those marks as starting points, children drew connections and created a circuit layout marking positive and negative connections. Finally they crafted and assembled their circuits and soldered electronic materials. This is a similar process for PCB design software where people mark the electronic parts and then draw traces for the connections, later assembling the components onto the board.

All the circuit creations looked unique as the children chose the positions and behaviors for the lights in their drawings. The process was longer but the children were deeply involved. Some got frustrated with the troubleshooting and their peers supported them. Some circuits did not work and the children kept working on it the next day, fixing and modifying their circuits. In the reflection circle, they shared that they initially felt lost and intimidated, but as they dived into it, it made more sense to them. One 13-year-old shared that she felt really proud of her circuitry as she never imagined herself doing this kind of work and thought only professionals can do it. “It is hard but also easy”, she said.

Figure 13. An interactive scene (left) and its circuit layout (right) made by a 12 year old girl depicting a scene of a children’s park near her house.
Figure 14. Variations of circuits made by children with ATtiny microcontrollers based on their neighborhood drawings

Figure 15. Reflection timeline: Children looking at images from previous sessions and annotating their Reflections
In sixth session we transitioned from an exploratory phase to a more focused project phase. The children started developing and shaping ideas for their final interactive story. First, we looked back at all the work we did in the previous sessions and collaboratively created a reflection timeline annotating pictures from the previous session (Figure 15). I reviewed with the group all the sample circuits and the techniques we had explored over the past few days. I also showed additional tangible circuit examples made using ATTiny microcontrollers with different pre-programmed behaviors and sensors (Figure 16). These additional examples helped open the possibilities for children to get an idea of what else they could do with the programmable ATTiny chips.

![Figure 16. Example circuits made using ATTiny microcontrollers with different pre-programmed behaviors (left). A participant engaging with the example circuit with a trigger switch and lights turning on in random sequences (right).](image)

Children were also building on the ideas discussed in the previous sessions. For example the 13-year-old girl’s idea of representing rain with blue lights (Figure 8) and a switch to trigger lights to turn on in different patterns inspired a 12-year-old boy to create a rain animation using lights and a microcontroller. He used a pre-programmed ATTiny chip to make the LED lights light up in random sequence using a trigger switch aligned with the clouds in his drawing (Figure 17).
We also looked ahead and children stated individual and collaborative goals for the next sessions. I introduced storyboarding, encouraging the children to draw quick sketches of scenes in their story. I also suggested that they annotate the storyboard describing the scene and the electronic interactions in it. Children reviewed their reflection journals to spark ideas.
around the plot for their story based on their documented experiences, and then ideated scenes constructing their stories. Some of the children chose their first interactive neighborhood scene created using ATtiny 85 chip and framed a story around it.

Facilitators listened to children’s stories and questioned them about their experiences and what was the significant part of that experience. What happened and why was it interesting or important to them? All the facilitators spent some time with children while they explained their ideas and helped them unfold the ways to represent their experiences with technology. We probed specific questions asking children details about the electronic materials and the kind of interaction they wanted to create in their story. This helped me understand children’s connection between the electronic interaction and their associated meaning. It helped to establish the analogies between real life events and the actions around electronic components.

![Figure 18. Participants sharing their stories with the facilitators](image)

In the next three sessions, children worked on building their projects working on both visual and technical aspects of their interactive storybooks. We had some design critique sessions in between where children shared their work in progress with the whole group and got an opportunity to seek constructive feedback on their work. Based on the feedback, they iterated their designs. We also decided to share the stories with a larger audience. This added a performative aspect to their storied creations. There was also a shift in theme: until now the narratives were for children themselves but now their stories were becoming part of the message that they wanted to share with an audience.
I prompted them to take a moment to review the whole process and encouraged them to look at the annotated timeline, talk to their peers, and look at their journals. I suggested that they write on a piece of paper the activities they did in the workshop sessions and the things that they learned in the process.

Culminating this workshop series was a show-and-share event where younger children and other facilitators from the learning center gathered to watch the story-based performance put together by the workshop participants. The children shared their creations and narrated their stories. This event was later followed by an exhibition with demos where the children shared their learning process and the backend circuits for their stories.

Figure 19. Storytelling and sharing: Performances put together by participants to share their interactive storybooks
The children enjoyed working with the microcontroller and shared that soldering was the best part of the process. They found troubleshooting the most challenging part as they felt stuck and took some time to detect the problem. A 13-year-old boy shared that he spent two days to fix one of his circuit with the ATTiny chip. Using a multimeter to check his connections, which all were connected. He then figured out the problem: he had placed the chip inverted. He said that once he figured out what the issue was, he was able to fix it in just five minutes. He and other children found that once they figured out the problems, fixing them was less challenging.

The children were very proud of their storybooks and felt that the lights made them more beautiful. They shared their wish to continue working on circuits to make bigger things. When I asked what do they mean by bigger things, one participant said, a book as tall as me. Some children mentioned working on other things such as cars, electricity in their homes, and video game consoles.
4.2 Case Study: The Water Story

Petal is a 12-year-old girl, who participated in this workshop series. She did not have any prior experience with electronics or computational media. She joined us on the second day of the workshop and she was the youngest of all. When she came, she was excited to see that everybody was making drawings with lights. Her peers were making drawings with multiple LED lights arranged in parallel. She did not want to start making a circuit with just one light. She was sure she wanted many lights like everyone else. Her peers and facilitators helped her get started with her first circuit with LED lights arranged in parallel and she made a glowing Sun with Yellow and Red lights (Figure 21-left)

![Image of Sun with lights](image)

Figure 21. Artifacts made by the participant in the workshop series: A circuit representing the Sun (left) and a circuit-based emotion map of a tree using conductive tape, a buzzer, and a pressure sensor

Later she engaged in the empathic projections activity where she emotionally associated herself with a tree and projected her personal feelings in her electronic drawing using conductive tape, a buzzer, and a pressure sensor. Her tree would generate sounds based on how gently or forcefully she pressed the pressure sensor expressing her feelings (Figure 21-right).

As the workshop progressed, Petal was introduced to new forms of interactions with complex circuitry with switches and pre-programmed microcontrollers that would give her...
lights and buzzers different behaviours, making them light up in various patterns. While she was being introduced to these tools and skills, she was also connecting them to her personal experiences. She made a map of her neighbourhood highlighting various events in one of the sessions. She annotated what she saw, heard or touched in the neighbourhood and how she felt. She was particularly hooked on the problem that was related to the availability of water in her community. For her final project, she built on that issue and constructed a story based on what she experienced around the community water faucet.

She looked back at all the electronics and circuitry that she explored in the initial days of the workshops and recrafted them into her story (Figure 22). Her initial sketches included the following events:

1. Women are standing around the community faucet to fill water in empty pots.
2. Women start arguing and fighting to get water first.
3. Their children witness the fight and they get involved in the fights.
4. The community leader comes and lectures women to stop them from fighting.

Figure 22. A storyboard created by the participant.

Petal's story demonstrated the problem in her community but she did not have a climax that provided the solution to the problem. Initially she was fine with it. Her friend was working with the sound sensor using it to represent a scene in the story that she was working on. This intrigued Petal to try a sound sensor too, and she wanted to include a sound sensor in her own story. Her friend provided guidance to make the circuit. Petal altered her story in order to have a scene with the sound sensor. She added a sound sensor in the climax scene in the story.
Through her drawings, Petal illustrated a story that starts with a scene from her neighbourhood where women are gathered around a communal water faucet to fill water in empty pots. There is no organized system so the women are standing randomly around the single water source. She highlighted the key action in the scene using a simple circuit. When the reader presses the faucet, the pot starts making a noise that represents the empty pot is getting filled with water coming from the faucet.
Petal’s drawing showed what she observed in her neighbourhood, capturing the visual feel of the place. In addition, with the use of simple electronic components, such as a buzzer and a switch connected with the conductive tape, she not only captured the sensory feel but also actions associated with the place at visual, tactile, and auditory levels. Petal placed the switch on the faucet connecting the live action of a person opening the faucet with their hands to the action of the reader pressing the faucet (switch) with their hand. The sound from the buzzer represented the sound of water falling into the empty pot. Petal can be seen as creating what Nicholas Roukes (1982) calls a Logical Analogy at multiple levels. She captured similarities between the diverse elements of the scene from her neighbourhood and the various electronic components in her circuit.

Petal continued to follow the same process to construct other parts of her story. Her next drawing (Figure 25) shows women, some with their children, standing across the road. One woman has fallen on the floor.

Figure 25. **Second scene with text:** People fight with each other and get into fisticuffs or physical fights.

Here again with her circuit interaction, Petal shares a deeper message. Petal demonstrates that the women are arguing and fighting over the water. She strategically placed the LED lights in the position of mouths of women in her drawing and added multiple switches...
underneath her drawing aligned with the sketch of the road. As soon as the reader slides their fingers over the drawing back and forth, the lights blink on and off vigorously. This interaction is used to show the women fighting and arguing on the road.

Petal can be seen as creating an Affective Analogy (Roukes, 1982) between her interactive drawing and the actual scene. She associated the emotional state of the women, in this case anger, with the active blinking of the lights and created a dynamic interaction. Petal’s circuit includes ten lights and multiple switches connected in parallel. Her circuit incorporates the “OR” switch logic where you press any switch in the circuit in order to complete the circuit that makes the attached LED lights turn on. When you slide the fingers across multiple switches, the LED lights turn on and off as you alternate between different switches. The faster action of alternating between the switches by sliding the fingers over can give the fierce animated blinking effect to the lights.

In her third scene, Petal shows a man in the centre gathered by the women.

Figure 26. Third scene with text: Talevar (Head of the community) intervened and tried to bring about a solution. He said do not fight and water will definitely be there in the faucets so solve the problem for now amicably and do not get into fights.
In this scene, Petal used multiple yellow and red lights placed in a circular pattern next to the drawing of the women. She did not use any switch or other kind of interaction. I asked her the reason for arranging the lights in circular form. She said that she just wanted to make the Sun. When I asked her how the Sun was related to the scene, she did not say anything. To me, it did not seem like a logical combination between the lights arranged as the Sun and the man standing in the middle but such composition evoked questions about the role of the man in the centre. From the visual with lights it appears that the man was at the spotlight that reflected his power. When I asked her who the guy was in her drawing, she said that he is the community leader talking to the women so that they stop fighting.

In her final scene Petal shows all the women standing in the queue near the water faucet.

Figure 27. Climax scene with text: Now everyone has water in their pots.

In this scene, Petal visually highlighted the fact that everybody will get water if they stand in queue by placing blue LED lights in the pots representing water. She demonstrates another crucial fact using a sound sensor. She placed the sound sensor hidden under the faucet (Figure 28). When the reader whistles, shouts, claps, or makes any kind of noise, the LEDs light up. When asked why she used the sound sensor, Petal said that she wanted to show someone managing the water queue and making sure everyone has water.
Figure 28. Circuit for the climax scene (Figure 27). It includes a sound sensor (electret microphone) and multiple lights connected to an ATtiny 85 chip.

Through this new medium, Petal shared her thought-provoking story about water issues in her neighbourhood in Bangalore Slums. She created a new type of performance that engages the reader at multiple sensory levels by bringing dynamic interactions with tangible electronic components.
4.3 Analysis and Reflections

Children who participated in the workshop demonstrated great interest in engaging with the Paper Electronics medium. When asked what was the best part of the workshop, some children mentioned bringing interactivity to their stories, some were sparked by new materials such as lights and sensors, and some of them considered learning new skills such as soldering as the highlight of the experience. All the participants showed great curiosity to learn about new materials such as lights, conductive tape, and microcontrollers. For some children, stories served as the entry point motivating them to learn new skills, while others were motivated to get hands-on with electronic components and learned to represent personal experiences while engaging with electronic materials.

Children created stories inspired from the events they observed and experienced in their everyday lives. They used Paper Electronics to create dynamic representations such as water flowing in a river or rain falling from the cloud by animating lights in different patterns. They playfully engaged with the new materials and expressed critical issues that were meaningful in their lives such as water shortage and its impact on their community. Petal's case study in particular suggests that she was not only inspired to learn new skills in order to express her story but also that her interest in exploring new materials like the sound sensor motivated her to envision solutions to the problem, adding a climax to her story.

Figure 29. A participant looking at her work and writing what she did and what she learned from the workshop sessions.
Children’s artifacts and journals revealed deeper understanding of electronics, artistic, and computational concepts. For example: a 12-year-old girl through her documentation reflected her understanding of electronic concepts such as the flow of energy, the polarity of the LED lights, and parallel circuits (Figure 29). While creating the circuits, children applied computational concepts such as AND/OR in order to give different behaviors to the lights and events stating relationships between input devices (sensors) and output devices (lights and buzzers) using microcontrollers.

As the children were creating their stories, they were applying the narrative concept of Flow highlighting a series of events that happened in their lives. They learned to create tangible representations using technology to present these experiences engaging the audience at multisensory levels. Using sensors, they brought different gestures and interactions to their stories.

While creating their projects, children were learning to develop certain practices. They learned to seek patterns and connections between the things they experienced in their lives and the circuits. They used microcontrollers programmed with Touch code to reconstruct a scene in their neighborhood seeking similarities between the light behaviors and the actions in their neighborhood. They learned to analogize events in their lives using electronic circuits at logical and affective levels. They were learning to empathize, emotionally connecting with the objects and situations, using circuits to express emotions.

In the process, the children learned to explore new materials and their properties. They discovered things they didn’t know before, such as the LED light has polarity, the current could only flow in one direction, the copper tape is conductive while the adhesive at the back of the copper tape is not. Children learned to playfully engage with the medium, experimenting with various connections and iterated on their process in order to get the desired effect. They learned to test the electrical connection using a multimeter and formed their own troubleshooting strategies to fix a problem.

Children were also able to reflect on their experiences and share their learnings with others. They created complex circuits such as animating raindrops using a microcontroller, building on their peers’ ideas. While they were explaining their ideas, they were questioning
and evaluating their process seeking feedback and suggestions from other children. Children were also sharing their learnings with other children, teaching them the concepts and practices that they developed.

In the process, children learned to bring personal meaning to their creations, presenting their experiences in interactive and dynamic ways. By creating artifacts such as Light-Up Self Portraits, they were sharing aspects of their identity with Paper Electronics. They were also learning to question themselves about their experiences and the significant part of their experiences in order to highlight those experiences with electronic interactions. Through their stories, they shared the relationship between the electronic interaction and their associated meaning.
In this chapter, I detail the design of a workshop series that introduced StoryMaking with programmable projections. I then share the story of two participants’ experiences, highlighting how they engaged with the medium while designing a project representing their common experiences. Finally, I share my own reflections and analysis of the workshop series, highlighting the concepts and ideas that the workshop participants engaged with.
5.1 Paper Theater with Digital Projections Workshop

This workshop series introduced StoryMaking through the combination of 3D paper art and the Scratch programming interface. In this workshop series children put together a narrative performance that had two components: a stage made up of 3D paper art, and digital animated characters made in Scratch. These two components were later brought together using digital projections. Children animated different characters in Scratch and projected the animation onto a 3D paper background. This workshop series explored the possibilities of bringing together physical interactions on paper and computational interactions in the Scratch environment.

These workshops were also part of the Drishya summer camp series. The theme of the workshop series was 'My World', focusing on children creating a story based on a day in their routine lives that featured an unusual event. The workshop participants created collaborative paper-based theatrical performances sharing their stories using digitally projected Scratch animations. This performance idea was inspired from 'The Icebook project' by UK-based artists Davy and Kristin McGuire that combines paper pop-up art with digital projections to create miniature animated theatrical performances.

There were 14 children ages 9-12 years old who signed up for this workshop series. Participants in this workshop were much younger than the previous group at Drishya and communicated only in Kannada language. I continued receiving support from two Drishya facilitators and one Project Vision team member to help with the facilitation. All but three participants were newly enrolled in the Drishya learning center and were less acquainted with the organization’s philosophy and pedagogical approaches. There were 12 male participants and only 2 female participants as there were few female students in the center within that age group. These children were very interested in drawing and paper craft. This group of participants was transitioning to this workshop from another camp where they were introduced to Scratch and MaKey MaKey for the first time and had some familiarity with

3 The Icebook was the world’s first projection mapped pop-up book. http://www.davyandkristinmcguire.com/

4 MaKey MaKey is an invention kit that enables to turn everyday objects into a key. http://makeymakey.com/
the Scratch Programming interface in the context of creating audio-centered projects.

The structure of the workshop was similar to the Interactive Storybooks with Paper Circuit Craft series with some modifications. This workshop series had 7 progressive sessions, each lasting 5 hours with breaks. I tried to keep regular opening and closing sharing circles, but it was challenging for this younger group to explicitly talk about their experiences. We started the day with focused tasks such as drawing meditation, going on silent walks in the neighborhood, or humming together. We ended each day with documenting their process in design journals. We encouraged reflection through design critiques where children would share their sketches and prototypes seeking feedback from their peers and the facilitating team.

In the first session, children made pocket-sized journals that they kept with them throughout the workshop to document their ideas and learnings. Some of the children did not have much experience with writing. Some wrote phrases, some wrote sentences, and some drew pictures. We made it part of our daily practice to pause in the middle of the sessions and at the end of the sessions to document our experiences.

![Figure 31. An example of a reflective journal created by a 10 year old participant.](image)

On the first day, making a journal was followed by an activity where I asked each child to draw a sketch of their neighborhood. I then asked them to choose a partner and share their description of their drawings with their partners. I told them to then make a collaborative drawing that combined elements from both of the drawings to form a new drawing capturing their common experiences. They then shared the new scene with others (Figure 32). Through this activity, I wanted to model the process of creating a collaborative
narrative. In the later half of the sessions, each pair made a 3D depiction of their scene using paper.

Figure 32. Children working on a collaborative drawing combining elements from two separate drawings.

In the second session, I gave a brief overview of Paper Theater and introduced some pop-up techniques. I also showed an example of a 3D paper model with Scratch animation projected on the paper model. Since the children were familiar with the Scratch interface, I simply revisited the concepts of a Stage and Sprite. In Scratch, motion is associated with 2D characters called Sprites while the Stage or background remains static. In the workshop, the paper models were to be the Stage on which the dynamic Sprites were to be projected. I made it clear to them that the stage is in the physical world and sprites are part of the digital world. I suggested that they identify the dynamic elements in their paper projects and create a Scratch project to animate the dynamic elements as Sprites.

The children then iterated on their physical models and created a Scratch project with sprites for that physical scene. They later experimented with projecting the Scratch animation aligning with the paper models. For example, one participant wanted to show a warrior in a palace. He made the palace with paper and used Scratch to draw and animate the warrior. He then positioned the warrior inside the palace using the projector (Figure 33).
In this exploration, children started analyzing their scenes and noticed several problems in the stage construction. For example, some paper models needed more surface to serve as screen for the projections. Some of the children said that their projections were not aligned with their paper models.
For instance, two girls wanted to show children playing at the park in their neighborhood (Figure 34). Their paper model had the background as well as characters and they had issues with matching the positions of the characters in Scratch animation with the ones on the paper model. Also the distance between the projector and the screen depended on the size of the paper model. In the third session, the children focused on fixing such intricate details, and mostly syncing the two worlds.

In the fourth session, children used their first scene as project starter and created a story around it. Facilitators listened to the participants’ ideas, questioned them about their experiences, and asked how they were planning to combine the two mediums. The children first created a storyboard, then shared their stories with the group and sought feedback and then discussed design for their physical projects.

The next two sessions were focused on building the paper projects and creating the Scratch animations. Children in groups made a pop-up books depicting different scenes in the story and Scratch animations about the action happening in each scene. The next step was to combine both the elements and syncing the two worlds. The workshop culminated in a show-and-share session where children did a performance to share their stories.

5.2 Case Study: The Fish Story

Two participants in the workshop series were Orion and Cosmos. While they both had some experience creating Scratch projects, they had little idea about what they would be doing in the workshop. However, they were excited to make things and be with their friends. On the first day, while making his personalized journal, Cosmos shared with the group his love of working with paper craft and was keen on doing more paper-based projects. He liked Scratch too but preferred working with his hands. On the contrary, Orion did not consider himself much of a hands-on person. He shared that he loved working with computers. In the previous Scratch workshop he attended, he enjoyed working with sounds while creating his Scratch projects and shared that he wanted to explore more sounds and maybe record some new sounds.

5 The names of the participants have been changed and Orion and Cosmos are pseudonyms.
On the first day of the camp series, Cosmos made a drawing of a Kere (Lake) that he watched everyday from a bus on his way to school. His drawings depicted what he imagined was inside the Kere, including a coconut tree, a snake in the grass, and a boy standing a bit further from the snake. He shared that it was a drawing of himself in a village where he saw a snake for the first time and was really scared. They both shared the stories of their drawings with each other. Orion was familiar with the lake in Cosmos’s drawing, and Cosmos told Orion that he was also scared of snakes. They discussed how they could combine their scenes and made a new drawing. The new drawing depicted the scene around the lake that both of them were talking about with a snake near the lake and a boy chasing the snake (Figure 35).

![Collaborative scene made by combining two individually created drawings](image)

**Figure 35. Collaborative scene made by combining two individually created drawings**

Both the participants then identified the moving characters in their drawings and discussed how to make a 3D representation of their collaborative drawing. They later made a 3D representation of the scene in their drawing and a Scratch animation with their characters.
In the Scratch program, they created a sequences of actions to show one character chasing another. They later projected the animation on the paper pop-up and realized that the characters were not placed in the desired positions. They iterated on their project and were later satisfied to see that the Scratch animation and the paper scene almost aligned.

Cosmos and Orion both felt confident after creating their first project. Cosmos shared with his peers his idea of changing the action on the computer by touching the paper model. His peers and mentors suggested that he could use a MaKey MaKey board to make it happen. Orion was excited about the idea too, but at that time they both did not know how to do it.

Cosmos and Orion then started brainstorming ideas for their final interactive story project. They wanted to include some parts of their initial project in their final story but not the whole project itself. Orion was intrigued by a pet shop near his house which had fishes
for sale. They created a storyboard for their project and took pictures of the drawings from their storyboard to use as a reference to create Scratch animations. They also made a prototype of the paper pop-up to test whether the movement in the animation matches the position of objects on paper (Figure 37).

Figure 37. Stages of the project development (from left): A 2D drawing on paper, a Scratch animation with the 2D drawing as background, and a 3D paper representation of the 2D drawing with the Scratch projections

After iterating on their designs several times, they made a final version of their 3D pop-up story book that had four scenes based on 4 different locations. Their story was about two friends’ mission to rescue fish from the pet shop and liberate them in the sea. Cosmos and Orion had 4 paper pop-ups and 4 different Scratch animation files. They then started preparing for their theatre performance. They realized that it would break the continuity of their performance if they had to do one scene, then change the paper stage and reset the Scratch projection opening a different file. As a result, they decided to merge all the Scratch files into one project and bind a paper pop-up book bringing together all their paper models of different backgrounds. Merging the Scratch files into one was a difficult task and it took them a long time to figure out a technique to change the scenes. They used events in Scratch to shift from one scene to another.

Now their animation was ready and they could control different scenes using the arrow keys from the computer. Cosmos and Orion found a new challenge though. How would you change the animation, when you flip the page of the storybook? They wanted to parallel the action of changing the background on paper with the change of scene in the animation. They both thought that the interactive MaKey MaKey board could help solve the problem. However, they did not know how to make the electrical connections seamless so that it
would not show the MaKey MaKey board and the wires. Also, the camp was coming to an end and it was almost the time for the performance.

In their final performance, they wanted to show this seamless interaction between the paper pop-up book and the Scratch projection. They made a mock-up performance by manually paralleling the action on the computer with the gesture of flipping the page on the book to change the scene. Orion was narrating the story as well as managing the key controls to change the scene on Scratch animation. Cosmos took charge of flipping the page and interacting with the pop-up book when Orion changed the scene by pressing the arrow keys on computer. Both these interactions were flawlessly synched.

![Image](image_url)

Figure 38. Scenes from the final story project made using Programmable Projections

Cosmos and Orion wanted to take their project to the next level. Even at the last session, they were asking their mentors to help them to make an actual interaction between the computers and the book without showing the wires. In the process, I got an opportunity to constantly engage in conversations with them as their project was progressing. I noticed that Cosmos and Orion were curious to understand ways of connecting the digital world and the physical world and were determined to make it happen. They tried many different things and failed multiple times but still kept going. I was curious to know what was motivating for them.

While they were working on their project, an external teaching member who was visiting their center asked Cosmos to describe his project. Cosmos along with Orion gave a brief about the story. The teaching member wanted to know about the technique and asked the children if they could tell him what technology they used. In response Cosmos insisted that
he wanted to share his story first. I could not help but wonder, what was motivating for these children? Were they inspired to learn the techniques, or were the actions in the story inspiring them to learn the computational concepts.

Figure 38. Participants discussing their project design

In this case, story was a starting point that allowed the children to explore tangible actions on paper and engage with computational concepts while working on their project. In their animations, they used a sequence of instructions with Scratch blocks to animate a scene. Later they used different events such as pressing the arrow keys to control the actions. Then they paralleled the digital action of changing scenes on the computer with the tactile action of flipping the pages.

In the process, Cosmos and Orion explored stage craft, paper craft, and computational craft. When I asked what they would want to do next, they said in unison that they would want to change the scene automatically when they flip the page. Orion shared that he now wants to make a story focused on himself and the snake.
5.3 Analysis and Reflections

Using programmable projections, the children explored the events they experienced in their lives and represented things that they wanted to communicate to the world about themselves. This workshop led to the emergence of a new type of engaging narrative performance bringing physical, digital and personal elements together. The children appreciated the collaborative aspect of StoryMaking where each of them got an opportunity to talk to each other about real events in their lives and connect with each other through those experiences. Children identified common aspects of experiences that were meaningful in their lives and constructed a new story building on their shared experiences.

Although the children had seen their teachers using digital projectors to show presentations and videos, they were surprised that the things they create on a computer screen could actually come alive in the physical world using the same projector. Most of the children did not have much experience with the computers before they participated in the workshop and there was a remarkable difference in their ability to program with Scratch at the end of the workshop. They were motivated to explore the medium, but were more excited to share their stories. For most of the participants, the performance was the highlight of their workshop experience.

As the children were learning to relate and express their personal experiences by creating collaborative stories, they were also further developing their programming skills with Scratch. In order to combine different scenes in their stories together, the children learned to put together different set of programming code to create animation in Scratch representing the scenes in their stories. The case study reveals that while creating projects, the children were engaging with new computational ideas such as creating sequence of instructions with Scratch blocks to animate the characters, using multiple events to change the scenes in their story, and paralleling digital actions on the computer with the physical actions on paper. The children also learned paper-engineering skills such as creating a 3D representation from a 2D drawing and creating various pop-up mechanisms.

While making their projects, the children added a series of incremental changes applying the skills they were exploring at different stages of the workshop. They progressively
transitioned from simple to complex steps. These included imagining a scene, representing
the scene in a drawing, creating a 3D paper representation of the scene, creating a Scratch
representation of the scene, projecting the Scratch animation on the paper representation,
and combining multiple scenes.

In the process, children learned to share and reflect on their personal experiences and
skills in order to co-create their project. They shared the challenges they were facing and
sought feedback from each other. The medium required constant tinkering and
experimenting. The children tested and iterated their ideas many times in order to match the
Scratch animations with the paper model. They also discovered new things about the
projector. One of the participant shared that the distance between the projector and the
screen is proportional to the size of the projection. More distance will create larger
projection, less distance with create smaller projections. As the workshop progressed, the
children felt more confident about working with the medium and envisioned ways of adding
more complexity.

In this workshop, stories served as the starting point for the children to acquire new
programming skills. They selected certain events in their lives that they had in common with
their project partners and represented them with programmable projections. They engaged
in recognizing and introspecting important aspects of their personal experiences. As the
children explored new computational ideas, they also created new situations hybridizing and
fictionalizing their shared experiences in their stories. Through their story based projects, the
children also envisioned and communicated with an audience how they would act in those
new situations.
Chapter 6
Sewable Circuits

In this chapter, I describe a workshop that introduced StoryMaking practices to the facilitators using Sewable Circuits as a medium. I then share a case study highlighting a facilitator's creative exploration towards designing a personally meaningful project using Sewable Circuits. I also share the participants' feedback on the StoryMaking process along with my own reflection and analysis.

6.1 Workshop: Textile Narratives

I led a StoryMaking workshop at an annual conference hosted by the Computer Clubhouse Network, an out-of-school learning environment where young people from underserved communities work with adult mentors to explore their own ideas, develop new skills, and build confidence in themselves through the use of technology (http://www.computerclubhouse.org/). This workshop was targeted towards facilitators to introduce the StoryMaking process using Sewable Circuits as a medium and to share the StoryMaking design practices later with their local youth members and adult volunteer mentors. Participants designed and created a collaborative story-based textile mural with interactive new materials including LilyPad MP3, an Arduino compatible microcontroller that enables adding audio to e-textile projects.

It was a full-day workshop session and four facilitators participated, three females and one male. Each participant had previously done some hands-on maker activities with the youth at their Clubhouses (and two had participated in earlier workshops with myself and other Lifelong Kindergarten researchers at Clubhouse Network professional development trainings). They had some experience in working with basic circuits and parallel circuits. Some of them were also interested in sewing. They were keen to learn new skills in the area of e-textiles, especially the LilyPad microcontrollers and were interested in the idea of
combining electronics with storytelling. The workshop gave me a chance to engage with each of the participants in one-on-one conversations to understand their learning process and get feedback on the StoryMaking process. As I was introducing each activity, I was explicitly stating its facilitation intention.

We started the session with an opening circle where participants shared their backgrounds and one activity that has become their family tradition. To begin, I briefly described my own family tradition of sharing 3 resolutions with my family members at the breakfast table on New Year's day. Participants shared their favorite family traditions mostly around festive occasions like Thanksgiving, birthdays, and New Year's eve. I later introduced StoryMaking with the overview of the session. I also showed an example project that I made using the materials that they were about to use during the sessions. The sample project demonstrated the interaction between input components like a press switch and reed switch and the output components like LED lights and the speakers using LilyPad microcontroller. The switches triggered the LED lights to turn on and the speakers to play a specific audio file. The project shared a story using electronic components that were embroidered on a piece of fabric with the electric connections visible.

The participants received a kit that had new materials to be used for the mural. In the kit, I included the main components for the mural such as pre-programmed LilyTiny MP3 board, SD card to record audio files, sensors, speakers and lights, sewing materials including conductive fabric and thread as well as prototyping materials like copper tape and alligator clips. The kit was supported with the common craft construction supplies. After a short break, participants were then engaged in a guided visualization where we all sat comfortably and tried to recollect the sensory feeling of their favorite family tradition that was shared during the icebreaker. I later told them to draw a scene on paper that captured the memory of the family traditions and identify the key elements with an LED light and a fabric press switch. I later demonstrated how to make a fabric switch using conductive fabric. Participants made examples such as a quiche, grandma's face, and a calendar to share the memory of New Year breakfast, Thanksgiving dinner at grandmother's house, and a son's birthday. They later added the switch to a circuit in their drawing (Figure 39).
Using their drawings as a reference, the participants then started constructing their stories. At this stage, participants had an idea about the electronic components they would be using for their project. They also brainstormed ways of integrating them in their stories and shared their ideas with their peers. In the rest of the session, participants worked on making their project. Nobody took breaks and it looked like everyone was involved.
They were using my example circuit as reference and remixing the circuit connections creating their own. They also recorded and edited songs and monologues that were part of their mural using Adobe Audition software. A lot of time was spent on troubleshooting and fixing. Towards the end, we had four interactive stories that came together to be part of the mural. Participants then shared their stories with the group.

In the closing circle, participants shared their reflections on the session. I asked them questions about their project, the workshop process, things they learned and their ideas for applying the StoryMaking process in their learning settings. I also shared a set of design practices that I developed for facilitating StoryMaking reviewing all the activities in the session. Some of the participants recognized the moments in the session where they saw the evidence of the practices and shared their thoughts and suggestions. I will describe each practice in-depth in the next chapter.

6.2 Case Study: A Facilitator’s Experience with StoryMaking

6.2A The Birthday Story

Sky⁶ is a lead facilitator and coordinator of a Computer Clubhouse informal after-school learning space who participated in the Textile Narratives StoryMaking workshop. She signed up for the workshop because she was interested in learning more about interactive textile projects. She had some experience in creating sewable electronic projects (she participated in earlier train the trainer workshops of mine around sewable circuits and wanted to develop her skills further. She was interested in the idea of creating story-based textile projects with embedded electronics because she was looking for ideas to develop new ways to motivate girls at her Clubhouse to create story-based projects with new, fabrication or “making” tools.

In the opening circle, when each person was asked to share a family tradition, Sky talked about her son’s birthday breakfast with gifts. When it was time to start creating, she looked at all the materials, asking questions about each electronic component and then chose the ones that she wanted to use for her project. She created a drawing that showed the scene of her

⁶ The name of the participant has been changed and Sky is a pseudonym.
son eating breakfast on his birthday with gifts around. Later she made a fabric switch in the shape of a calendar. She wanted to highlight her son’s birthdate. When her son’s birthday on the calendar was pressed, the light on the drawing would light up.

Figure 41. Participant working on her story based project with Sewable Circuits.

She later shared her project idea with the group. After seeking feedback and encouragement from the group, she worked on the visuals using felt fabric for the story of her son’s birthday. Using textile craft materials, she made a cake, gifts, and her son eating his breakfast. She added intricate details to her visuals that she proudly showed to the group, explaining that she had embroidered freckles on her character to make it appear like her son.

After working on the visuals Sky started laying out the electronic components on her project finalizing their positions on the layout. She was using a LilyPad MP3 board with one LED light, two speakers, a switch, and 4 reed switches (magnetic sensors). She later made a prototype of her connections with copper tape before sewing with conductive thread. She referred to an example circuit to design her own and asked the facilitators questions when she got stuck. After testing her connections, she wanted to record someone’s voice singing
the happy birthday song. She was initially hesitant but later decided to record her own voice wishing her son happy birthday using Adobe Audition software. She later started sewing her components using conductive thread.

Sky's project shows a scene of her son sitting on the table having his breakfast (Figure 41). There is a calendar showing his son's date of birth with a cake and balloons to show the festive aspects of the birthday. Her scene also shows many gifts that her son has received over the years since they started this tradition. The gifts have magnetic sensors. There is one special gift that does not have a magnetic sensor but a magnet instead. As the unique gift is brought closer to the other gifts, the LED light on the cake would light up. When the date on the calendar is pressed, the LilyPad mp3 plays the birthday song sung by Sky. Sky did not have enough time to sew all the circuits so she used alligator clips to complete her connections and share her idea.

Although, the overall idea was to create a collaborative mural project, Sky wanted to keep her individual story to bring home. She explained to the group that she wanted to give her interactive story to her son as a birthday present. She said that she was looking forward to her son getting to see and interact with it because the stories are dedicated to him. Sky's sharings revealed a deeper sense of connection the maker to her own interactive project through personal stories of unique experience and emotional attachment.
6.2b A Facilitator’s Feedback on StoryMaking

For Sky, the process of coming up with an original idea or project concept is the most significant aspect about completing any project. During the workshop Sky shared her reflections on her project and the facilitation process.

When I asked her what was the most exciting part about her project, she said it was integrating the audio in a story-based project. I further asked what did the audio add to the project and how was it different than just narrating the story. She answered that this project was different because it was interactive and that her story might be interpreted differently. When Sky was working on her project, she showed it to one of her colleagues and asked him if he could guess what her story is. Sky shared that her colleague’s interpretation was different than what she was trying to communicate through her story. “Sometimes we leave out little steps and it doesn’t tell a full story”, she added. I asked Sky whether she wanted the audience to have have a clear understanding of her story or interpret their own. She said that
she wants the audience to have their own interpretation. She said such artifacts can trigger their imagination and they can form their own story.

I later asked her how would she do this workshop differently in her own teaching settings. She said instead of doing a one-day session, she might continue this over several sessions. “These things take time,” she said. It was frustrating for her that she could not finish her project in the session. She added that she wanted her youth to understand the value of the process not just the product but also want them to have the satisfaction of finishing something. Her peers supported her point and suggested that may be there could be a design practice that addresses this point. I asked them about possible wording for this practice, and they suggested a phrase such as, ‘Start something, finish something, move on to something else.’

At the end of the session, I asked Sky and other facilitators the key take-aways from the workshop. Some shared that they explored new materials and learned new skills such as working with the LilyPad Mp3, magnetic sensors, and sewing. One participant shared that she had previously tried doing electronics-based projects, found it confusing, and struggled to remember few concepts. “I don’t get it and it is usually not intuitive,” she said. She appreciated that in the StoryMaking workshop I did not use any templates that simply told participants to follow step-by-step instructions. According to her, in the workshop the stories replaced the templates and in the process everybody figured out the technique and science concepts by designing something personal. “When it is personal, it is more motivating and valuable,” she said.
6.3 Analysis and Reflections

Through this workshop experience, I recognized facilitators’ enthusiasm in learning new skills with Sewable Circuits to represent their personal stories. Most of them had previously explored storytelling only in their personal practice and not as a medium to engage youth in learning new skills. However, they had explored making as a way of learning in their professional practice. They were keen to explore ways of representing stories using electronics and textile craft. They were interested in learning electronics, computation, and craft skills. They were more interested in learning ways to facilitate these skills.

The participants upon observation and reflection, expressed a deeper understanding of using a programmable microcontroller and electronic components to create visual, narrative, and computational representations of their personal experiences. As they were learning to sew electrical connections between electronic components, they were learning to sew a story about their favorite family traditions with a sequence of events. They were also remixing the example project, learning new techniques and applying them to create their own projects.

The participants reported that they were learning more about new materials such as Lilypad MP3 boards, magnetic sensors, and conductive fabric/thread. They were able to explain how input devices such as magnetic sensors and fabric switches were acting as triggers to cause the output devices such as speakers and LED lights to create an action. Working with audio was the highlight of the workshop experience for the participants as they felt it made the artifacts more engaging to the audience. They shared that the interactive aspect of their projects made the projects more engaging for the audience where they can associate their own meanings.

Participants were also able to reflect and share their experiences seeking feedback and encouragement from their peers. It allowed them to connect with the concepts as well as with each other in deeper ways. Through their personal projects, they shared with the group values and interests that were most important to them. Their projects were not only representing events in their lives but also significant relationships in their lives. They shared with the whole group upon reflections that the best part of having a physical representation
of stories is gifting them to those significant people who are part of their stories, allowing them to interact and connect with their personal meaning.

By the end of the workshop, they felt more confident about facilitating project-based activities with Sewable Circuits. They shared that the process of using stories was better than using templates, as you learn the concepts in an intuitive way by designing something personal. They found the design practices very valuable and expressed that the benefits of StoryMaking can be explored better if it is facilitated over several sessions and not just one. They also felt the need to start with simple explorations where children can be engaged in creating instantly gratifying but personal projects, and then progressively leading to complex projects in later sessions.
Design Practices for Facilitating StoryMaking

Based on the experiences and learnings from the workshops, I articulated a set of design practices that guide the framework for StoryMaking experiences with Tangible Computational Media. Below, I describe each of these ten practices. I explain the reasoning for each, and provide an example of how each was applied in the design and facilitation of the StoryMaking workshops.

1. Create a sacred space

Creating a sacred space is a metaphor for providing a comfort zone for children where they can feel free to connect, create and express themselves. It is a space for reflection, contemplation, and consciously connecting with the true creative self. A beginning ritual can help provide the setting for the sacred space. These rituals can be held at the beginning of the day, the start of an activity, or any other transitional time.

At Drishya, one of the learning centers where I led the StoryMaking workshops, this practice builds on an existing tradition. At Drishya, children start their day by creating a Mandala, a circular pattern on the floor with rangoli (colored chalk powder), flowers, and other found materials. Facilitators and children sit in a circle around the Mandala and meditate. Being part of Drishya inspired me to develop a practice that I call “The Circle Time” where everyone gathers and sits together in a circular arrangement to share their discoveries, creations, insights, and ideas. All the workshops always started with an Opening Circle and ended with a Closing Circle.
Sacred space is the group’s shared time together. It can include daily rituals such as a group activity in which children invent a song by humming together, or a hands-on activity such as a sewing circle or creating light-up paper cubes representing a personal event. Creating a sacred space is more of an attitude than an actual physical space. It is very flexible and facilitators can incorporate their own styles and methods depending on what is meaningful to them. Many participants considered the opening circle the highlight of the whole experience and said that it broke the wall of intimidation and allowed them to get to connect with each other in deeper ways.

Figure 42. Participants sharing their experiences in the opening circle (left) and light-up paper cubes created by participants representing a personal event (right)

2. Encourage sharing of personal experiences

Participants who came to these workshops did not come with a ready story that they wanted to share. Most of them did not even consider themselves a storyteller. They constructed their stories as they dived into making and sharing with each other.

To empower children to create personal stories, it is important to provide them a platform and accessible pathways they can comfortably develop a voice within and share their experiences. It is crucial for facilitators to understand where children are coming from and help youth document and reflect upon significant moments in their lives.

Facilitators could ask children to share about things such as their favorite places, an unforgettable dream, and their family holidays. These conversation starters with little
encouragement can give children opportunities to talk about the experiences that are personal and meaningful to them. These experiences could be shared one-on-one with the facilitator, amongst peers, or with the whole group. This practice makes children confident in sharing their stories.

In my experience, in some workshops it took only a couple of minutes, while in other workshops it took days to help the children feel comfortable and be open about their experiences. I noticed that children sometimes were hesitant to explicitly talk about personal things. StoryMaking activities with TCM, such as creating a self-portrait integrating a basic circuit or creating a Scratch animation describing a place in their neighborhood, allowed children to visually express their personal stories that they felt shy to communicate during circle time. Some children also shared these experiences in their reflective journals.

3. Spark ideas by sharing your own creative process

The process of exploring new materials and representing personal meaning with those materials is a complex process that requires thought and reflection. It could be intimidating for children to engage in such a complex process without some scaffolding. To provide this scaffolding, the facilitators can share their own process of how they engaged with new materials to represent personal experiences.

In the workshops, when I introduced an activity, I made sample projects to show the children. I always demonstrated the process that I followed to make my projects with them. What inspired my project? How did I start? What sequences of action did I follow to build my project? What was challenging? How did I resolve it? What was my story? How did I represent my story with the medium? When there were other facilitators helping me, I also encouraged them to make a project and share it with the children. Sharing multiple sample projects helped to communicate a diversity of possible project ideas and styles.

Children found this practice very helpful. Often they remixed the sample projects to make their own. They also felt more connected to the facilitators after hearing their personal stories and ways of communicating their stories with new materials. They also felt more comfortable in being exploratory and learning through mistakes as the facilitator modelled the process.
4. Be curious about others’ curiosity

In order to allow children to develop their own ideas and own the process they are engaging with, a facilitator needs to be an active listener. They need to show authentic interest in children’s curiosity. This practice is inspired from Eleanor Duckworth’s research. In her book Tell Me More (2001), she highlights the importance of the facilitator’s involvement as a listener for sustaining the learner’s interest in discovering something new and express what they are learning.

In the workshops, I noticed that there were times when the participants felt shy about sharing their stories and did not feel confident about their project ideas. Sometimes they felt stuck and could not progress further. At such times, children appreciated it when the facilitators valued their ideas by listening enthusiastically and by showing genuine interest in their discoveries. Children were also probed with questions that allowed them to crystallize their ideas and make tangible representation of their stories.

Facilitators can encourage children to share their stories by asking them about their experiences. This role can also be shared by peers, with facilitators suggesting prompts that encourage children to share their experiences with each other. Facilitators can dedicate some time to ask children questions about how they intended to use new materials and interactions to represent events in their stories. Facilitators can also encourage children to address the opportunities and challenges they deal with while designing their projects.
5. Introduce tools as a medium for Self-Expression (not just technique)

The focus of StoryMaking is not to teach children TCM itself but instead allow them to engage with the medium in order to express their personal experiences. As one of the educators in a workshop stated, “It is not about learning technology, it is about learning with technology.”

Through the StoryMaking process, children indeed learned technological tools and concepts but in intuitive and exploratory ways. I and the facilitators illuminated how children could express themselves with the technology. This was communicated well through activities such as creating a self-portrait where the facilitators introduced making a basic electrical circuit with lights as a way to represent superpowers. The empathic projections activity (see section 4.1) is another example where I introduced using a pressure sensor and buzzer through creating a circuit embedded in a feeling map.

Figure 44. A participant sharing her self-portrait created using basic circuit (left) and a feeling map created by a participant projecting himself as a snake and representing feelings using a circuit with sound and pressure sensor (right).

Through this process children not only learned about the tools and techniques but also the process of how to learn with these new tools and techniques. They can also find their own personal ways of connecting with these tools and applying them in their designs.
6. Provide creative constraints but leave room for open exploration

Constraints have a significant role in fostering creativity but too many constraints can also restrict the emergence of novel ideas. We often hear about the need for “out-of-the-box thinking” in order to unleash the creativity. However, I have found that one needs to first explore the constraints of the box in order to reach beyond it. Constraints and openness are both valuable for creative process; facilitators need to balance scaffolding with openness. One approach for doing this is to start with a focused activity and then expand the range of options as learners gain more experience over the course of a workshop, an approach that MIT Media Lab graduate Jay Silver (2014) calls being “close-started” and “open-ended”.

In the StoryMaking workshops, the activities had some constraints in materials and themes. For example, the paper electronics camp started with a focused activity of children making self-portraits using a defined set of materials: conductive tape, one battery, one piece of card-stock paper, and one or two LED lights. In other workshops, themes such as “my neighborhood” or “favorite childhood activity” served as constraints for creating stories. These constraints provided a starting point for children to tinker with the materials, and they then had the choice later to use a range of materials and interpret the theme in their own way and design personalized projects.

Facilitators can provide an environment where children feel safe working within the constraints, establishing familiarity with the materials and concepts but also provide them encouragement to go beyond those constraints, taking their projects further to explore multiple possibilities. Facilitators can design activities with enough structure so that children do not feel lost but also provide them some space where they do not feel controlled and can trust their own ideas.

7. Raise the Ceiling

The concept of “low floor and high ceiling” is often used to describe the Logo programming language. The low floor metaphor is used to describe experiences that are easy enough for beginners to get started while high ceiling indicates complex explorations for
experts (Resnick & Silverman, 2005). I use the same analogy of low floor and high ceiling to
describe the two extremes of creative explorations.

In my facilitation practice (before StoryMaking workshops), I had designed low-floor
activities to engage children in designing a variety of projects using simple entry-level
techniques. These activities helped children to get started becoming comfortable with new
tools and aspire to create high-ceiling projects. However, I realized that there was a need to
design a ladder (progressive explorations) that would allow children to gradually transition
from a low floor to a higher ceiling.

Facilitators can start with simple activities where children can design instantly gratifying
projects. Depending on the level of children's comfort and confidence, facilitators can then
introduce more complex explorations. For example: in the paper electronics workshops,
children started with exploring basic circuits and gradually explored complex circuits using
microcontrollers (Figure 45).

Figure 45. A project made with basic circuit using one light(left); a project made with a circuit using
19 lights, an ATtiny 85 chip, and a switch (right)

Raising the ceiling is a slow and thoughtful process and it can be challenging to apply this
practice in short workshops. In such cases facilitators can design at least two different kinds
of explorations where children could make an entry-level project and get started with a little
more challenging exploration that could motivate them to continue exploring further, even after the workshop. One needs to balance the level of complexity: if an activity is too easy it can be boring; if too complex it can be frustrating.

8. See Outwards; Focus Inward

Where do ideas come from? As makers, we have multiple sources for our inspiration: things that are unique, things that delight us, things that connect with us, and things that stay with us. What we see and feel in the real world can inspire our imagination. We might experience inspiration intuitively but it can be challenging to transform the inspiration into artistic expression. How can we make this happen? Stories can create a bridge to connect our real world and the imaginary world that we create.

StoryMaking encourages children to foster a sense of self and express themselves in richer ways. In order to express oneself, one needs to take a step back and start with finding ways to recognize the self. In my experience, children can find meaningful ideas by consciously looking at and consciously connecting to the self. In order to demonstrate this process, facilitators can give prompts pointing kids to look at something external and find ways to connect with personal experiences.

This can be achieved by doing activities like going out for a walk and drawing things that catch one's attention or capturing the sensory feel of the place (the smells, the sights, and the sounds). Facilitators can point at a particular place, character, or object and encourage children to record their thoughts and memories that are sparked through what they see. Children can later ideate scenes for their stories based on those memories. Thus, to help participants come up with ideas, facilitators can stimulate children to look around (externally), look within (internally), and look beyond (imaginatively).

9. Reflect in Action (not just on action)

Reflection is an essential design skill that enable us to pause, think, and learn from our experiences. It pushes us to zoom in, question, and evaluate our work, allowing us to generate insights. Mitchel Resnick (2013) highlights reflection as a critical part of the creative learning process where children engage in discussions to reflect on their design process and
thinking process. While it is important to reflect after completing the work, it is also crucial to reflect while the work is in progress. Schon (1983, 1987) suggests this concept, calling it “reflect in action” (while doing something) and “reflect on action” (after you have done it).

This practice was followed in the StoryMaking workshops everyday at different time intervals. In the Opening Circle, I encouraged children to reflect on the previous session’s experiences. During the Closing Circle, children shared the exciting and challenging moments of the day. Design critique sessions also fostered this practice. Through design critiques, children described their work in progress and received feedback from their peers and facilitators. This helped children to develop an understanding of their project and progress. It also allowed them to build strategies for proceeding further and refine their work.

This also links to the practice of being curious. Children appreciated when facilitators listened to their stories and asked questions about their experiences. Sharing with the whole group gave children confidence to describe their work. I also facilitated group sharing that helped to address common challenges and ways to resolve those challenges. One of the facilitators described the group reflections as “learning from each other and learning with each other.”

Reflections can also be done in other forms such as writing and drawing. Reflection journals played a significant role in fostering this practice. It also equipped children to evaluate their work. To make this happen, facilitators can give writing or drawing prompts. For example, I told children to write two column notes on what they did and what they learned in the process (Figure 46-left). Storyboarding is another example of an activity that helps children to reflect on what they would like to express. Children described their story scenes and wrote about the ways they would use TCM to show an interaction in that scene (Figure 46-right).
10. Look Back; Look Ahead

Looking back involves reviewing past experiences to reflect on them and looking ahead helps to develop goals and strategies for the future. This process not only helps children to iterate and refine their previous work but also to reimagine new possibilities to take their learning further and design new projects. It is adding the third dimension to the reflective process, what did I do, what did I learn, and what shall I do next?

In the workshops, I applied this practice of looking back and then looking ahead, incorporating it into the everyday routine, encouraging children to share individual and
collaborative goals during circle time. For workshops with multiple sessions, I facilitated creating a reflection timeline where children viewed pictures from the previous sessions, annotated their experiences, and wrote plans on Post-It notes about their next steps (Figure 47).

![Figure 47. Participants adding their plans for next steps on the reflection timeline](image)

Looking ahead also includes sharing about the long-term future goals. At the end of the workshops, I asked children to think about the ways they would apply the skills they have learned through the workshop experience. This allowed the children to consciously look back at the process and think critically about ways of applying their learnings in other contexts. In these discussions, children also shared about the ways they would extend their learning. They talked about the concepts they would like to explore next and projects they would want to build.
Chapter 8
Conclusions and Future Directions

This experience of engaging children in making personal narratives helped me reflect, research, and articulate ways of facilitating a sense of self with new technologies through StoryMaking. I explored how children engage with new technologies to create new forms of stories, understanding and expressing aspects of their worlds in unique ways. StoryMaking workshops allowed me to gain an in-depth understanding of the ideas and perspectives that the children were exploring while making delightful storied artifacts.

Through these artifacts, I learned how children used Tangible Computational Media to create stories that were complex, tangible, interactive, and dynamic. Some children shared stories inspired from real life events, some altered their realities, and some took inspiration from classic stories projecting themselves as protagonists. Using electronic components such as lights, buzzers, and microcontrollers and applying computational ideas such as random sequences, parallelism, and abstraction, children constructed their worlds, illuminating ideas they cared about.

By representing their personal experiences and reflecting on those experiences, children demonstrated skills and practices that they were learning. They explored new techniques to construct craft, electronics, and projections while also engaging with computational and artistic ideas. And more importantly they were learning to create ideas for self-expression, envisioning themselves and their worlds in new ways with creative confidence.

Children's stories revealed how they navigated their worlds and acquired new skills. I noticed that children were deeply involved in creating their self-narrative projects, being iterative, troubleshooting complex circuits, and expressing personal meanings. The projects
were their own and they found it very valuable. At no point did they look uninterested or
distracted. Sharing and reflection played a key role in the process and gave everyone a chance
to observe, relate, introspect, and express. I saw signs of perseverance and patience in many
processes including ideating the story, assembling the components, and troubleshooting. I
noticed passion and care when they shared their stories. Stories sparked and inspired their
making and learning of artistic and computational ideas, the tangible interactions made them
exciting and the personal connection made them more meaningful.

I observed that the process worked better in immersive workshop settings than the short
independent sessions. While the short workshops sparked interest in making stories with
new technologies, the long-term engagement through immersive workshops created
pathways to develop these ideas further and construct the self through narrative exploration.
I wish I had more opportunity to talk to children about how they would explore the benefits
of StoryMaking in their lives in the future. I aim to further unfold how StoryMaking
nurtures children’s creative self-hood.

Through my interactions with educators, I discovered their great interest in facilitating
these experiences. They said that participating in the workshops enabled them to embody
the StoryMaking experience and helped them to gain insights on how they could apply this
process in their learning settings. Some educators pointed out the challenges of applying this
process in mainstream classrooms. They appreciated having a list of design practices for
facilitating StoryMaking and expressed the need for resource guides with example activities
to help them get started.

I hope to further explore new technologies and experiences that can serve as narrative
mediums for self-expression. I aim to understand the impact of StoryMaking process in
children’s lives. I also wish to share these processes and pedagogies by creating a
StoryMaking facilitation guide demonstrating approaches, skills, and techniques for creating
personal stories using Tangible Computational Media. In the long run, I envision working on
other forms of support, such as workshops, demo videos, meetups and an online
community. From a research perspective, I am interested in studying how educators from
different communities facilitate these experiences using StoryMaking practices. I intend to
provide support to educators to further their own visions and situate StoryMaking with new technologies into their practices.

Designing StoryMaking experiences allowed me to understand children’s lives and the world around them through their creative meaningful explorations. While creating representation of their personal stories, children highlighted issues in their lives and their communities. This sparked curiosity in me to identify the impact of StoryMaking practices for community empowerment. I plan to find ways in which StoryMaking can translate from creative self-expression to community action. I wish to explore how children can communicate difficult experiences and complex emotions by constructing stories using new technologies. I look forward to further developing ways of supporting children through StoryMaking to be more confident, creative, expressive, introspective and self-aware, thus enabling them to become change agents in their communities. I dream of building a wider community of educators to support this passion.
Appendix: A
Tools, Materials, and Artifacts

Following are the materials for each Tangible computational Media category that were introduced in the workshops and the types of artifacts created using the medium.

**Paper Electronics**

Workshops focused on paper electronics included basic electronic components such as lights, conductive tape, lithium batteries and buzzers. I also introduced programmable microcontrollers ATtiny 45/85 along with making DIY sensors such as touch, pressure and sound sensors. Some workshops used Circuit stickers, light, paper-thin and flexible circuit boards with conductive adhesive on the back. The complementary assortment of materials included hot glue guns, conductive adhesive tape and soldering irons. Craft supplies included materials like scissors, glue, cardboard, quilling needles etc.

The electronic materials were combined with paper craft techniques to make artifacts such interactive storybooks, story frames and story-based installations such as a tree.

**Digital Projection with Scratch**

This category included paper pop-up art integrated with digital projection and Scratch (Resnick ETAL, 2009). Participants used computers with Scratch interface, LCD projectors and paper art supplies (such as card stock, scissors, paper cutters, glue, and cutting board). In the workshop, the techniques of digital projections with Scratch was introduced with Paper Theatre, a miniature theatre made with 3 dimensional pop-up art.

Participants created interactive paper theatre performances (https://vimeo.com/100400147)

**Sewable Circuits**

Workshops introducing sewable circuits included basic sewable electronic materials such as conductive thread/fabric, sewable battery holders, and lithium batteries. Preprogrammed LilyPad microcontrollers (LilyTiny and LilyPad Mp3 boards) were used for creating interactive audio and light projects. LED lights, speakers and magnetic sensors (reed switches) were also used with slight tweak in their form to make them sewable. Sewable electronic techniques were introduced along with textile art. The craft materials included assorted fabrics, needles, fabric glue, and embellishing materials like beads, sequins, and embroidery threads. For audio based projects, software such as Audacity and Adobe Audition was used to record and edit sound.

Participants in these workshops designed artefacts such as story quilts and textile murals (https://vimeo.com/126198415).
Appendix: B
Interview Questions for workshop participants

About Projects:
- What is your project and how did you make this?
- Can you tell me about what inspired your project?
- What was best about the project you made?
- What was the hardest part?
- Was your story different with lights/sound/sensors than if you didn’t have any of those in it?
- If yes, how was it different with lights/sound/sensors than without them?
- Using these material and techniques, what might you want to do next?

About personal experiences:
- What is an example of your most memorable event?
- Do you have a true story that you would like to share?

About the workshop:
- What did you think of the workshop?
- What did you think of the process (e.g. the steps you went through in designing and making this)?
- Were you able to explore the possibilities you wanted to explore?
- Are there ways that you’d change the workshop?
- How do you think what you did in this workshop relates to the other forms of storytelling that you have explored?
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References


