Building a System to Guide Reflective Interaction for Early Childhood Empowerment

Introduction. Young children have fantastically unique experiences of the world and their blunt perspectives can be leveraged for meaningful change.[1] My research in *child-computer interaction* and *constructionism* aims to **empower children in constructing their ideas and transforming their experiences into inventions**. The late computer scientist, Dr. Seymour Papert, formalized the theory of constructionism wherein "learners are particularly likely to make new ideas when they are actively engaged in *making* some type of external artifact—be it a robot, a poem, a sand castle, or a computer program—which they can *reflect* upon and share with others".[2,3] Much constructionism research has since focused on the "making" aspect of learning; researchers are developing and sharing new systems to support children in creating technological and tinkerer artifacts (e.g., Scratch Jr., MakeyMakey, Tactile Picture Books). However, the "reflecting" aspect of learning remains both understudied and undersupported in these emerging construction activities. This represents both incompleteness in the embodiment of constructionism *and* a missed opportunity—by reflecting on their creations and sharing their reflections with others, children can build their identities as inventors[4] while transforming their experiences into **avenues for social, technological, and environmental change**.[5]

Research Plan. I will build a system that (1) guides children in reflecting on their creations, (2) facilitates the sharing of reflections across multiple caregiving relationships (child-parent, child-teacher, child-sibling, etc.), (3) supports developmentally appropriate interactions for young children, and (4) integrates reflection into a wide range of existing and future systems of artifact construction. I will conduct my research with the methods and tools of *user centered design*, as well as *co-design with children*, and I will iteratively integrate my results into **usable prototypes** and a **set of design principles** to inform future research and development.

I have used my preliminary research and my background in early childhood education to **envision a future model of reflective interaction**: *A 4-year-old child, Max, creates an artifact in a makerspace activity and the activity facilitator invites Max to "tell a story" about her invention. In a quiet area of the room, a stuffed animal engages Max in reflective inquiry by asking her questions about her work. The stuffed animal uses human-recorded voice prompts, an algorithm to effectively administer the prompts, and natural language processing to listen to Max's spoken words and translate them into text. If Max speaks a language different than her activity group, the stuffed animal can ask her questions in her native language and create custom translations of her story for each of her language communities. The facilitator then prints Max a copy of her story. At the end of the activity session, Max shares her invention with the group and the facilitator reads her story; the group asks Max questions about her ideas. She goes home to her family with both her invention and her story. Max's family members read the story with her and learn more about her interests and her developmental needs. They might model the reflective inquiry in their home activities using a puppet, as well as share the story with her speech therapist or her school teachers to add to her portfolio and to influence new curriculum. Back at the workshop, the facilitator iterates on his activity design using Max's insights on her goals, needs, and experience.*

Since April 2016, I have collaborated with two master's students, two preschools, two libraries, and a Mini Maker Faire to conduct formative research. My methods include work observations,

user interviews, contextual inquiry, ethnography, personas, storyboards, and usability testing. My preliminary research has resulted in: (1) 26 reflective inquiries with preschool children producing 26 stories shared with both teachers and families, (2) a mapping of the children's recorded reflections to *computational thinking* skills such as decomposition, abstraction, and algorithmic thought, (3) a *graph network diagram* representing the caregiving relationships supported in my proposed reflective inquiry system, (4) an *abstract state diagram* that describes an algorithmic application of reflective inquiry with a young child, and (5) a design for a low-cost, *customizable tactile puppet* that guides a caregiver in engaging, customizing, and recording the inquiry.

I will conduct my Ph.D. research with (at least) three distinct learning communities to generalize my solutions across diverse populations of young children who are constructing with varied creative technologies. To ensure success in this goal, I will extend my connections with local preschools, makerspaces, libraries, and Science Discovery Center workshops in order to build for diverse needs. I will begin by creating a prototype for globally-situated children in the Tactile Picture Books Project — a 3D printing research initiative that serves children with visual impairments, many of whom have adopted families. This initiative lacks support for reflection.

Assessment. My success criteria are tied to understanding and meeting my four research objectives described above. Any unmet or partially met objectives will require further analysis and **insights gained will be integrated into my resulting design principles and prototypes**. In my analysis, I will conduct *usability testing* with children, caregivers, and technology developers to assess ease of use, engagement, and output. I will also review the interactions using the *Developmentally Appropriate Practice*[6] criteria and technology position[7] from the National Association for the Education of Young Children to support meaningful development across cognitive, language, social, and emotional domains. Finally, for fun, I will use the *K-12 Core Computational Thinking Concepts and Capabilities*[8] to map the children's reflections to computational thinking foundations in order to assess how the system might foster these skills.

Intellectual Merit. I will contribute formative research on an understudied area of learning in underserved populations to support reflection in the construction of ideas. Furthermore, I will formalize a method for children to contribute to technology and interaction design by sharing their reflections on their experience. My efforts will yield both a system prototype and a set of design principles that can be used to inform future research and development on constructionism. Finally, I intend to publish and present my findings at conferences for Human-Computer Interaction, Child-Computer Interaction, and Computer Supported Cooperative Work.

Broader Impacts. With each iteration of my user centered design cycle, young children will meaningfully reflect on their inventions and share their stories with their own *round table* of caregivers. And with every story shared, there is new insight on how to better support early development through tools, technologies, curriculum, and caregiving. By gifting children—like me as a young girl—with an opportunity to voice their ideas, this work will empower young people with diverse needs, backgrounds, and perspectives to make sense of and transform their experiences by building their skills, seeing their strengths, and crafting their visions of the future.

[1] Druin, A. et al. (1998). [2] Kafai, Y. B. & Resnick, M. (1996). [3] Emphasis mine. [4] Roque, R. (2016). [5] Guha, M.L. et al. (2004). [6] Copple, C., & Bredekamp, S. (2009). [7] Radich, J. (2013). [8] Barr, V. & Stephenson, C. (2011).