Connecting Tinkerers: Enriching Maker Communities through Neurodiversity

Annuska Zolyomi
The Information School
University of Washington
Seattle, WA 98195, USA
annuska@uw.edu

Abstract
The Maker Movement is a vibrant community of Do-It-Yourself tinkerers inventing gadgets, proudly sharing ideas, designs, and tools. Although the Maker Movement is potentially a rich avenue for autistic individuals to build and demonstrate their skills, a more intentional approach to neurodiverse Making would enrich the Maker community's ability to learn, invent, and make. In this position paper, I examine three Maker projects through the lens of theories used in Human-Computer Interaction, Cognitive Science, and Learning Science. These Maker projects are avenues for autistic individuals to express not only their creative and technical skills, but also their capacity for executive functioning, social interactions, and Theory of Mind.

Author Keywords
Autism Spectrum Disorder; Theory of Mind; Maker Movement; Learning Science; Embodied Interaction.

ACM Classification Keywords
H.5.2 User Interfaces: Prototyping, K.3.1 Computer Uses in Education.

Introduction
The Maker Movement is comprised of communities of technology enthusiasts using open-source software and fabrication tools to create personalized solutions. The

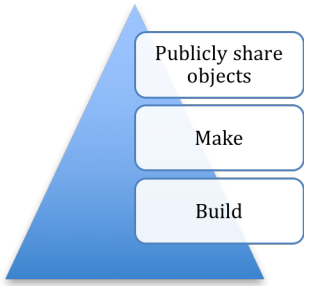

Figure 1: Constructionism is core to Maker projects

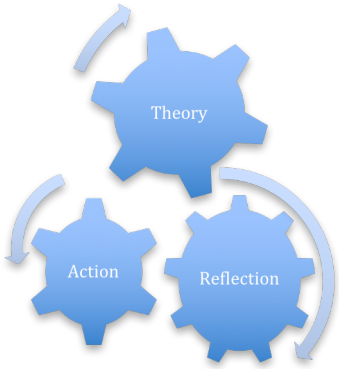

Figure 2: Cyclical Praxis process supports critical pedagogy

Maker Movement is an important force in the U.S. pipeline of science, technology, education, and math (STEM) innovation [6]. The Maker Movement has the potential to be open to all people; however, care should be taken to intentionally include people who are often left behind in technology advancements, namely people with disabilities. I focus on including autistic individuals in the Maker Movement because some autism-related traits, such as logical thinking about deep interests, align with technology aptitude [5, 6]. Some autistic individuals have strong visual skills [4, 8], which are valuable assets for designing Maker projects.

The HCI field has an opportunity to build connections towards a goal of inclusive Maker communities through research and design explorations. As an preliminary investigation, I examine three Maker projects through the lenses of theories used in HCI, Cognitive Science, and Learning Science. The projects are: (1) learning fundamental electronics prototyping, (2) building a geolocation gadget, and (3) creating an e-Textile responsive skirt. My analysis demonstrates that Maker projects provide valuable opportunities for autistic individuals to exercise skills that are often taught through therapy: social interaction, executive function, and Theory of Mind [1]. Making is an avenue for exercising these skills "in the wild," motivated by an individual's personal interests.

Theoretical Frameworks for Making

To frame my analysis, I apply the theories used in Learning Science identified by Paulo Blikstein [1] as being applicable to Making: constructionism, critical pedagogy, and experiential education. I also draw upon embodied interaction and Theory of Mind because of their potential to illuminate constructs of autism.

Learning Science Theories

Constructionism is the theory of constructing knowledge through activity [1]. This knowledge construction (Figure 1) gets to the essence of Making. To support intense personal engagement, learning environments must support diverse learning styles.

Critical pedagogy advocates for students to think critically about societal influences that are barriers to their empowerment [1]. By examining their individual experiences with social contexts, students can gain perspective and take transformative action. Termed "Praxis," this reflection on theory and action (Figure 2) leads to constructing culturally meaningful objects.

The educator and philosopher John Dewey [3] developed the theory of experiential education, claiming, "There is an intimate and necessary relation between the processes of actual experience and education" [3]. Through active learning, experiential education draws upon personal experiences and the development of abstract concepts. Experiential education engages students of all learning styles.

Embodied Interaction

Embodied interaction theory views our physical movements and interactions as coupled with our intelligence, cognition, and visual processes [9]. This theory is a tool for researchers to analyze individual expressions, interpersonal communications, and group activities.

Theory of Mind

The ability of an individual to form a concept of self, and others, is referred to as the psychological Theory of Mind [1]. One's concept of self is formed by one's

Figure 3: Teenagers at Ryther summer Arduino workshop intensely engaged on building circuits.

Figure 4: A depiction of electronics processor to drive a geolocation gadget. Tagged locations would be viewable to Google Maps.

beliefs, intentions, knowledge, etc. Theory of Mind supports our ability to view others' perspectives and to have empathy, which can be challenging for autistic individuals [1].

Illuminating Learning and Skills through Maker Projects

I review three projects that cover a range of learning and implementing Maker skills.

Arduino Electronics Prototyping

In 2013 and 2014, I taught Arduino workshops in summer camps for Ryther[1], a Seattle therapy clinic providing services for neurodiverse children. The workshops were 90 minutes, split into two sessions. Each session was attended by a maximum of six students. Each student had use of an Arduino SparkFun Inventors Kit[2], which includes an Arduino processing chip, an electronic breadboard, and electronic components (wires, LED lights, resistors, input (e.g., light sensor), and output (e.g., buzzer) components). Each child had a pamphlet of projects. Although I structured the workshop to proceed in order, some children took a quick affinity to the concepts and jumped ahead to pick projects that piqued their interest. The material and ability to work independently supported diverse learning styles, which are critical components of constructionism and experiential education. The children received immediate feedback from the electronic circuit because either the components (e.g., lights) worked or not. The children explored concepts of electricity through trial and error, and I could see experiential education and critical pedagogy in action. Embodied interaction was evident in their outward expressions. They had to negotiate using the shared tools, such as battery packs. Their non-verbal body language communicated when they were seeking additional electronic components to complete their circuit. Viewing them hunched over their circuits (Figure 3), I saw clearly that they were engaged in learning and experiential education.

GeoTracking Gadget

This is a prospective project where children would be guided in creating a tool to track their location and pathways in a built environment. The logged geolocation data would be stored in the cloud and viewable in Google Maps (Figure 4). The motivation for the project is to support counter-mapping activities that give children a voice in local city planning [10]. The children's pathways provide the city planners insights into the children's lived experiences. For instance, users might tag a location that blocks their desired pathway.

This project would support critical pedagogy because the children would design a mobile gadget they would willingly use and carry in their neighborhood; the gadget would be in a form factor that is culturally acceptable. The children would construct knowledge of how the gadget works on-the-go, concretizing their ideas of how to interact with the gadget to tag locations. In seeing their path through Google maps, they would see the abstract concepts of geotagging visualized in the virtual world. A child's Theory of Mind would be reinforced as they view their own pathway and that of other children. They would gain perspective of what other children experienced in the built environment as they moved through it.

e-Textiles

The final project is designing and creating an e-Textile skirt that responds to the wearer's movements. This is a skirt I created in collaboration with a textile artist, Jacqueline Calladine. The skirt had LED lights sewn in, along with a Lilypad Arduino[3] processor and accelerometer (Figure 5). As the person wearing the skirt moved, the lights flashed at a relative rate. If an

[1] http://www.ryther.org/
[2] https://www.sparkfun.com/products/12060
[3] http://lilypadarduino.org/

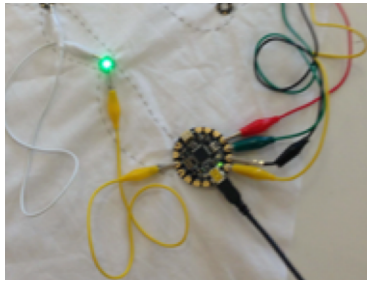

Figure 5: Our e-Textile skirt during prototype phase

inclusive Maker team was creating this e-Textile, they would exhibit embodied interaction in several ways. For instance, the team members would communicate through their gestures around the textile, pointing out how the lights should be laid out and connected to the Lilypad processor. Embodied interaction would be evident as they decide upon the form factor and style of the garment. They may hold the prototype up to their bodies to evaluate its position against their bodies and to feel the texture and electronic components. They would anticipate how their movements would change the behavior of the lights, thus engaging in executive functioning and experiential educational. They would be anticipating social interactions and developing Theory of Mind to imagine how another person would react to the skirt.

Discussion

In my initial, high-level analysis of three Maker projects, I have identified points where individual explorations and team collaborations bolster experiential education, constructionism, and social interactions. Autistic individuals' intelligence can be illuminated through embodied interactions, such as negotiating the shared use of electronic components and exploring the physicality of an e-Textile skirt. We can build Theory of Mind and critical pedagogy by encouraging autistic individuals to form their unique design ideas and observe interactive designs. Naturally, Maker projects are often free-flowing and unstructured to some extent to leave space for creativity and personal expression. The social interactions and negotiations benefit from facilitation to support a team's learning and communication styles. Careful planning, and building in flexibility, is needed to present the concepts and materials to support the children in Making at their individual paces while building towards a team goal.

My analysis of Maker projects demonstrated opportunities to build skills often challenging for autistic individuals, such as executive functioning (planning, seeing the big picture, etc.), recovering from failure, collaboration skills (brainstorming, team forming, resolving conflict, etc.), and developing Theory of Mind (seeing others' perspectives, taking turns, etc.). My analysis also showed that Maker projects can bring out natural skills of autistic individuals, such as intense personal engagement, interest and aptitude for technology, and logical thinking.

Conclusion

Examining three Maker projects from HCI and Learning Sciences theoretical perspectives illuminated learning opportunities for autistic individuals and Maker communities. My analysis is evidence that this topic warrants further HCI research and design and has the potential to build connections supporting inclusive, neurodiverse Maker communities.

Author Biography

Annuska Zolyomi is a first year Ph.D. student at the Information School at the University of Washington. She has a Masters in Human Centered Design and Engineering. Her research focuses on accessible human-computer interaction, especially technology-mediated solutions for the autism community. At this workshop, she seeks to understand, and help shape, the community's goals and approach to inclusive user experience. She hopes to explore methods, such as participatory design and value sensitive design, that deeply consider users' perspectives.

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