What to Design Next: Actuated Materials and Soft Robots for Children

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A growing interest in soft robotics and actuated materials in human-computer interaction (HCI) has generated several projects that demonstrate the capabilities of pneumatically-actuated robots. For this technology to have an impact on non-researchers, there is a need to consider how to develop soft pneumatic robots in order to accommodate the abilities and interests of children. We argue that through designing soft robot kits and applications for children, the field of programmable matter will progress as a more accessible, playful technology. This workshop paper describes the impacts that soft robotics for children may have on: expanding what materials and techniques are used in soft robotics, new types of "post-processing" techniques for customizing soft robots, and educational applications for soft robotics.

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1 INTRODUCTION

Soft robotics as a field in HCI is focused on the design, fabrication, and testing of highly compliant materials. Several initiatives have grown the soft robotics community through knowledge-sharing initiatives and toolkits [3, 10, 17]. These resources provide detailed information on the fabrication process to create the hardware system as well as the soft material. These initiatives have targeted researchers and makers who have the knowledge and tools to fabricate the system. A focus towards designing these technologies for children, specifically their interests and available materials, can diversify the types of soft robotic projects that are made.

Computational technologies that integrate the interests of children, their toys, activities, and culture have the potential to be more accessible and increase participation [6]. Traditionally, designing technology for children has focused on educational benefits, where novel systems have been integrated into classrooms to aid students in learning design, programming, and fabrication. But children do not spend all their time in classrooms, and these educational tools are separate from the types of play, tinkering, and making that students do outside of school. Children modify technology to fit their lives and interests, as designers, it is important to create systems that support a wide range of interests and skills.

Soft robotic toolkits and applications designed for children could generate several insights that will benefit the field, including:

- Expanding what materials and techniques are used in soft robotics
- New types of "post-processing" techniques for customizing soft robots
- Educational opportunities for soft robotics

2 OPPORTUNITIES IN DESIGNING SOFT ROBOTS FOR CHILDREN

2.1 Expanding What Materials and Techniques are Used in Soft Robotics

Creating compliant materials for soft robotics is an involved process that uses fabrication techniques such as 3D printing, laser cutting, and molding. While there has been an increase in availability of these soft robotic prototyping technologies [9], designing material morphology with these tools requires technical expertise and extensive time, making it impractical for children. This leads to the question: if children are unable to design their own soft actuated materials using predominant fabrication techniques, how can we support them to create soft robots? Efforts have been made to create soft robot construction kits for children with modular components [12]. Software tools for modeling and simulating soft robot actuators [2] could also assist in the process. We propose focusing on the materials that children already have at their disposal, this option presents an interesting opportunity for soft robotics, as these hacked materials could lead to novel types of actuation and new form considerations. Several of the toys found within a child's classroom or home are similar to materials used in research and commercial soft robotics projects. One could imagine students cutting open sensory stress balls to create simple jamming interfaces, modifying party horns to create linear actuators, or adding a balloon to a hoberman sphere to create a shape changing exoskeleton (Figure 1).

Fig. 1. Example of toys that a child would have access to for hacking into soft robots. At left (a): a sensory stress ball. In middle (b): an extendable party horn. At right (c) a hoberman toy sphere.

Members in the maker community have generated tutorials that use low cost craft materials to fabricate compliant materials. Two tutorials were created by a student who identified that soft robotics has barriers related to cost and access to fabrication tools [7, 8]. In response they developed a low-cost soft robotic gripper that is based on a fiber-reinforced actuator research project [15]. The project demonstrates similar capabilities while also being made using cardboard, hot-glue, curling ribbon, and other craft materials (Figure 2). The other project uses a ball point pen to fabricate a soft robotic tentacle (Figure 3). These projects demonstrate the resourceful fabrication methods that do not require professional tools.

Fig. 2. Soft robot fiber-reinforced gripper made by Instructables user “Harrison_89”. At left (a): silicone casted in a cardboard mold. At right (b): The gripper being used to pick up a rubik’s cube.

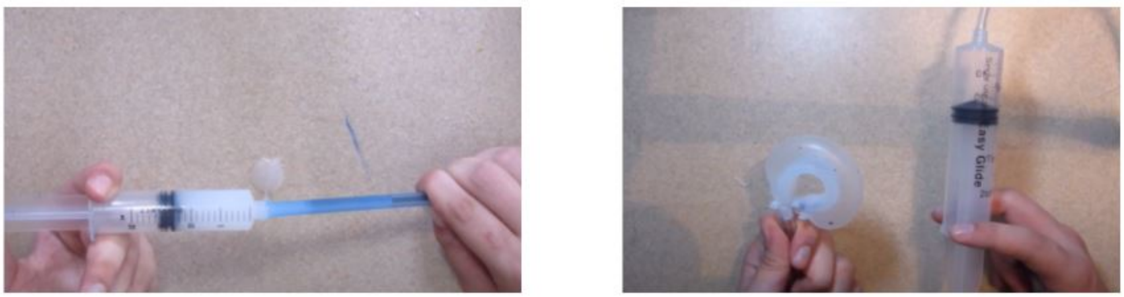

Fig. 3. Soft robot tentacle made by Instructables user “Harrison_8”. At left (a): silicone injected into a modified ballpoint pen mold. At right (b): The Tentacle being actuated by a syringe.

2.2 New Types of “Post-Processing” Techniques for Customizing Soft Robots

Using current soft robotic systems and materials, students can only create a certain type of project. By putting this technology in the hands of children, we could see an exciting intellectual shift towards morphing soft robotics into new types of artifacts. For example, imagine a child that has an interest in the tropical ocean and wants to use soft robotics to create a realistic model of a puffer fish. Current soft robotics systems and tools are not particularly good at supporting this project: you can convincingly create the inflatable movement of the fish, but it will not look much like its real-life counterpart.

What new tools can we create to assist in the embellishment of soft robots? There could be new techniques to embed scales or fur onto the surface of a soft robot. Tools to design and embed simple structures into soft robots could enable storytelling opportunities and immersive interactions. The point being that by designing for children and their interests of decorating and embellishment, soft robotics becomes a design medium. Children like making things that move [14], they also value the ability to combine their creations with a range of craft and other materials. This enables them to customize their creation, make it unique, and representative of the interaction they envision.

2.3 Educational Opportunities for Soft Robotics

By designing for children, we expand soft robotics toward education and play. We propose two scenarios where soft robotics could benefit student during learning: toolkits and tangible learning tools. Soft robotic toolkits have been used to teach materials science and mechanical engineering concepts to children [11, 12, 18], a majority of which focus on fabricating the material and using syringes to actuate the robot. We propose extending these learning opportunities by adding computation. Systems as simple as a servo-driven pump have the potential to interest students in programming. Once the student has learned to control the pumps they may move onto integrating pressure sensors or additional soft actuators to create more complex systems. Another opportunity is to modify current soft robotics actuation toolkits to be used with popular block-based programming languages like Scratch [4] or MakeCode [1], which can simplify the programming process for beginners and promote tinkering [16].

Workshops and classrooms that utilize soft robotic learning tools could create unique educational experiences for students. For example, a planetary sciences workshop aimed at teaching students about gravitational forces could utilize a wearable jamming display to constraint the elbow joints of the wearer, creating different types of movement sensations [13]. Students who are learning to calculate areas and volumes of various geometries may deepen their physical intuition for these mathematical formulas using pneumatic displays, for example, engaging with how a cone has one-third the volume of a cylinder with the same height and radius through the amount of air required to pressurize each geometry. Learning opportunities that utilize soft robotics could benefit students by providing a tangible learning that connects knowledge building with direct experience [5].

3 CONCLUSION

The novel materiality and nature-inspired design process of soft robotics is aligned with the possibility of imaginative and playful interactions for children. Soft robotics, as a younger field, is still presented with fundamental challenges both in terms of the technology and its accessibility. We see this as an opportunity to probe more creative, perhaps imperfect, and surprising designs. Through the practice of designing soft robots for children, we can provide new insights for the field of soft robotics.

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