Empowering Older Adult Crafters to Electronically Enhance Artifacts

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ABSTRACT
Even though older adults possess the skills necessary to work with technology, a toolkit that enables them to create electronically enhanced artifacts has not yet been developed. We present an electronic toolkit designed specifically for older adults that enables them to create electronic objects with a customized function. We recruited N participants (X female, Y male) from senior living communities and crafting groups from a rural Midwestern town. Participants were ages K to J (median age = M) with no cognitive impairments and were actively making an object with their hands. Utilizing a participatory design approach, we conducted three workshop sessions in which participants 1) taught us about their craft, 2) learned about electronics, and 3) participated in a joint brainstorming and prototyping session. From the participatory design workshops we found that participants were interested using electronics for aesthetic effects or to create objects with a custom function. To modularize the toolkit, we added two hard bases and one soft base. The toolkit includes three outputs and four inputs as well as the LilyPad Arduino. Our toolkit is customizable, as it can be integrated into three-dimensional objects, while still remaining modular so that those unfamiliar to electronics can use it.

Categories and Subject Descriptors
H.4 [**Information Systems Applications**]: Miscellaneous; D.2.8 [**Software Engineering**]: Metrics—*complexity measures, performance measures*

General Terms
Theory

Keywords
older adults, crafting, electronics, prototypes

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1. INTRODUCTION
Older adults are capable of independently designing wearable devices, but an electronic toolkit designed specifically for their demographic has yet to be developed. Maker technology is a burgeoning field and several kits have been developed for children, such as MakerWear [12], littleBits [2], EduWear [11], and MakerShoe [13]. These toolkits are accessible and abstracted to make electronic tinkering easy; however, they are physically constrained with limitations on inputs and outputs. These toolkits are intended for school-aged children and consist of modular building blocks that alleviate connection issues, but also hinder open-ended creation. Mellis et al. [17] forwent this modular design and created an "untoolkit" aoppealing to the user's creativity while avoiding strict construction techniques. While this approach allowed for greater innovation, the result was a less abstracted kit that required a greater knowledge of electronics to use. Other electronic kits have been developed for a variety of ages, such as the LilyPad Arduino [4], circuit stickers [10], and MaKey MaKey [22]. The latter was evaluated with older adults and while older adults found the kit enjoyable, they had reservations about its suitability for their age [21]. These toolkits are geared towards a variety of audiences but often require guidance or prior programming knowledge. We propose a maker toolkit designed to enable older adults to explore the possibilities of integrating technology with tangible objects.

We employed a modified participatory design method in our workshops in an effort to further develop a relationship with the participants and gauge their abilities. Our augmented participatory design method included an initial session in which participants taught us about their craft by presenting various artifacts. We also conducted standard sessions where we introduced participants to electronics concepts and held a joint brainstorming session. Using information gathered from the participatory design workshops, we designed a toolkit that empowers older adults to create and personalize their own technological devices.

Our work contributes the following to the HCI community: 1) a thorough description of our modified participatory design method, 2) a detailed description of the process for creating the toolkit and the contents of the toolkit, and 3) qualitative analysis of participant activities and interactions utilizing the maker toolkit.

2. RELATED WORK
We frame our related work around creativity and maker technology. Maker technology is discussed in terms of tangible visualizations,

maker technology for children, and generalized maker technology.

2.1 Creativity

The combination of technology with craft in art therapy has gained recognition as a means of minimizing the social isolation and loss of personal identity that people with mental impairments experience [18, 25]. However, art therapy does not only compensate for deficiencies in health. Especially when enhanced by technology, art creation can encourage people with mental impairments to share personal thoughts and emotions, even in situations where they would normally feel isolated or detached from the rest of society [8,16]. For example, the Third Hand is a practice in art therapy that empowers and enables the desires of the client, encouraging creative thinking without focusing on health deficiencies [15]. We drew upon the concept of the Third Hand and the role that technology plays in enabling inclusion in a larger community when designing our toolkit, ensuring that it promoted creativity and affirmed older adults' abilities as innovators. However, our toolkit is designed for the general older adult population rather than just those with mental impairments.

Engaging in creative activities has proven health benefits. Several studies report that participating in the creative arts is associated with higher cognitive function as compared to a control group [7, 19]. Additionally, cognitively stimulating activities can reduce the risk of Alzheimer's disease [24, 26]. Participating in creative activities provides health benefits to older adults; however, toolkits harnessing creativity have not been developed for older adults.

2.2 Maker Technology

One predominant precursor to our work is the development of "Maker Technology." Maker technology generally consists of a toolkit of small electronics, such as the LilyPad Arduino [4], that do not require advanced knowledge of programming or electronics to use. Maker technology allows the user to build customized objects that have an enhanced meaning and specific purpose [1].

Previous studies regarding designing artifacts and maker technology in general found benefits to working with tangible visualizations. Lazar et al. [14] found that older adults were satisfied by leisure activities that resulted in tangible products, such as knitting. Participants cited tangible benefits as the reason they enjoyed working with e-textiles [20]. Brereton et al. [3] conducted a study with engineering students engaging in design project work and found that engineers learn by comparing their knowledge of the physical world to unfamiliar theoretical models. Although the study was conducted with engineering students, the results, which point to the importance of physical objects in design, can be extended to older adults as well. In addition to the benefits of creating with tangible objects, previous studies have explored the creation of tangible visualizations of health. Running data is transformed with Activity Sculptures into three-dimensional representations, resulting in increased motivation and self-reflection [23].

While designing toolkits to introduce children to electronics and encourage the creative development of tangible objects is a burgeoning research field, there is a dearth of toolkits designed specifically for older adults. littleBits is one example of kits catered towards school-aged children [2]. They consist of pre-programmed electronic modules that snap together with magnetic connections, allowing participants to "play with electronics without knowing electronics" [2]. MakerShoe and MakerWear expand upon this concept by allowing children to plug hexagonal modules into shoes and other items of clothing to create different effects [12, 13]. Quilt Snaps is a textile-based toolkit developed to expose children to electronics [6]. These kits allow children to be creative without fully understanding electronics, a crucial aspect of maker toolkits. Additionally, maker toolkits for children were often more effective when the children were invested in creating their wearable. Eduwear, a toolkit designed for the construction of wearable technology, capitalizes on this principal by enabling children to create personally meaningful artifacts [11]. Building on this finding, Anathanarayan et al. [1] found that children who spent over 90 minutes creating their wearable device used it more often. The field of maker technology for children is expanding, but these kits are unsuitable for older adults as the applications are centered on children's interests and the method of connections limits the possibility of fully integrating the modules into preexisting objects.

Maker technology has also been developed for a broader audience. Circuit stickers are pre-programmed modules connected through a common substrate and designed for prototyping purposes [10]. They provide a novel interface but are somewhat untested for integration in three-dimensional spaces. Some maker technology, such as MaKey MaKey, has been studied with older adults, but while they enjoyed playing with the technology, they felt the kit was more suitable for a younger audience [21]. When older adults were working with MaKey MaKey, instead of brainstorming potential applications, they noted that they would like to share the experience with their grandchildren. Mellis et al. [17] took a less structured but equally creative approach to toolkit design by developing an "untoolkit," which appeals to the user's creativity and encourages the artistic design process to a greater extent than traditional kits. The "untoolkit" required programming knowledge and was designed for two-dimensional spaces, limiting both the audience and the potential applications. Maker technology developed for broader audiences lacks the ability to integrate into 3D objects or requires programming knowledge.

In addition to maker toolkits, technology designed for integration into textiles has been developed for adults. The LilyPad Arduino allows for easy creation of e-textiles as the electronic modules can easily be sewn into fabric and connected with conductive thread [4]. New techniques for attaching electronics to textiles to create wearable devices such as PCBS, electronic sequins, and socket buttons have been developed [5]. This technology allows for the easy integration of electronics into textiles but does not include a modular design, making connections difficult and requiring knowledge of circuits.

3. BACKGROUND

To better understand the needs and abilities of older adults, we conducted initial observations with five distinct crafting groups and administered a survey. Through our observations we established rapport with the crafting groups and we were able to recognize important aspects of their groups structure, groups support, and artifact sharing. We administered a survey to a broad audience to create an age-based comparison regarding crafting habits, interest in technology, and interest in health. The results of these initial observations and survey informed our decision to gather further information via a participatory design workshop to find out more about how an electronic toolkit would be used.

3.1 Observations

Our target population for our observations was groups with at least 40% of their members over the age of 65 and whose aim was to craft a tangible object. We bridged the gap of understanding how older adults could create using electronics by focusing on a subset of older adults who are already creating things with their hands. This group can then take what they learn and design their own health-improving devices using what they already know. This can result in a series of devices that are more context-appropriate and personalized to individuals' lifestyles.

Over the course of 10 weeks, we observed five distinct crafting groups and 45 participants (44 female). We visited each group at least twice for an average of 2 hours at a time. At the beginning of crafting sessions, researchers introduced themselves and received verbal consent. No incentives were provided. Researchers conducted ethnographic-style observations during sessions. Three researchers, two not associated with observations, iteratively analyzed the observation field notes using an affinity diagram method.

From our observations, we noted important aspects regrading group structure, group support, and artifact sharing. Group structure was split into three categories defined by the overall function of the group - independent projects, collaborative projects, and class style. The way groups supported their members came in several different forms. The most common form of support was facilitating help between participants. Some groups had a show-and-tell style session that helped members elicit feedback from each other. Supporting beginner crafters was also a crucial function of these groups, but the groups differed in terms of who was expected to help. Each group shared artifacts they crafted differently, both within the group and to others outside of the group. Sharing within the group was often done to solicit feedback on a project and provide validation that a crafter belonged there.

By observing, we learned about older adult crafting groups and how leveraging established groups could support teaching older adults new skills by reflecting how they currently create. Being sensitive to the way they structure their groups, support members, and share artifacts can help to create a supportive environment for older adults to learn new skills.

3.2 Survey

To complement our observations, we conducted a survey exploring older adults' habits, their interest in technology, and their interest in health. We recruited participants from the observation groups, social media, and snowball sampling. Our target population for the survey was anyone over age 18 who was creating a tangible object. We allowed for a broader age range for comparison between ages. We collected 142 unique responses. Forty-one were over the age of 65 and 137 were female. The respondents had a wide variety of primary crafts, but most were knitters(65), sewers(22), crocheters(20), and quilters(11).

From our survey we learned about older adults' preference in how they craft. One notable difference between older adults to those younger than 65 is that a higher percentage of older adults looked to magazines for help and online videos and social media less.

4. METHODS

We conducted modified participatory design workshops to understand the needs and abilities of older adults. Each workshop consisted of three sessions in which we 1) learned about the crafting habits of older adults, 2) taught them about electronics, and 3) held a joint brainstorming session.

4.1 Participatory Design Workshop

We recruited older adult crafters from a rural Midwestern town and the surrounding area by reaching out to recreational centers, senior centers, and assisted living communities to participate in a series of workshops to occur outside of their current crafting group times. We recruited N participants (X female, Y male), ages K to J (median age = M). Z participants completed all parts of the study (X female, Y male).

The workshops consisted of three two-hour sessions and focused on 1) understanding their crafting habits and practices, 2) building their knowledge of small electronics, and 3) prototyping ideas of how they would electronically enhance their craft.

In the first session, participants taught us about their crafts in a show-and-tell manner followed by a focus group discussion about their crafting. Additionally, participants filled out a survey on demographics, crafting habits, and familiarity with technology.

The second session was focused on teaching the participants skills relevant to small electronics. We demonstrated how to build paper circuits and taught some basics of electronic circuitry before participants created their own light-up birthday cards. Next, we introduced some basic Arduino components and walked the participants through an activity using a pre-programmed Arduino Grove Kit from Seeed Studios. Participants were asked to fill out a pre- and post-test to evaluate their confidence working with electronics.

Finally, in the third session we created low-fidelity paper prototypes based on their ideas. To facilitate idea generation, participants were encouraged between sessions to take pictures or videos of ideas in their own homes to share. Participants were also encouraged to bring in items that they would want to enhance with electronics. These ideas were shared in a brainstorming session to help inspire participants, after which they created low-fidelity prototypes using office supplies, pre-cut shapes (e.g. an Arduino), and sample physical components like LEDs. We concluded with a questionnaire asking for feedback on the workshop as well as specific questions about their health interests.

The workshop was analyzed using an affinity diagram to analyze themes. Survey data was analyzed with descriptive statistics and the pre-post test for the second session was analyzed using a paired t-test to validate whether or not the participants improved their understanding of electronics.

4.2 Toolkit Design

Using information gathered from the participatory design workshops, we prototyped a toolkit to allow older adults to create personal electronic devices independently. To experiment with various electronics from LilyPad and determine how each component should be modified, we created two exemplar objects.

The first object is a medication box with light sensitive LEDs. The LEDs will turn on when the box is open or if the box has not been opened in twelve hours. The first prototype of the medication box was laser-cut from cardboard. We added a circuit with LEDs, a light sensor and a LilyPad Arduino. We sewed all components by hand and the circuit was sealed by a cotton fabric panel so only the power switch was accessible. The first prototype functioned as originally envisioned, but was not accessible to re-program or to change the battery. Additionally, sewing all the components by hand was difficult.

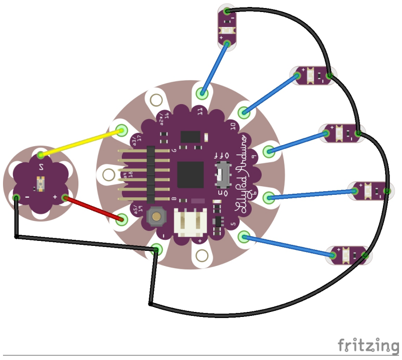

Figure 1: Circuit For Medication Box

For the second version we wanted to make it easier for a beginner to make the box. The second prototype of the medication box was made from laser-cut balsa wood. We soldered snaps onto the LilyPad Arduino components and sewed the corresponding female snaps into a fabric underlay. We sewed from each snap to a strip of conductive fabric to make it easier to use the LilyPad components in a sewing machine. Additionally we used puffy paint to color-code each component, indicating power, ground, digital, and analog. The second version was easier to assemble but the lid of the box was too small to use the sewing machine so we cut the strips of conductive fabric and sewed between them by hand. Some issues arose in the second box with connectivity as the components were larger and some conductive thread crossed.

The second object was a pair of "see-in-the-dark" 3-D printed glasses. When placed in darkness, an LED in the front of the glasses lights up. Our motivation behind creating the glasses was to demonstrate how the LilyPad and its associated sensors can be attached to harder materials in different configurations. We chose to make the glasses light up in the dark because of the recurring theme of lights that we observed in the participatory design workshops. The first prototype of the glasses included a fabric patch on which the LilyPad Arduino and the light sensor were sewn together using conductive thread. This patch was attached to the side of the glasses using non-conductive thread. The LilyPad and sensor communicated with the LED, which was connected to the front of the glasses using non-conductive thread, through long strands of conductive thread that hung below the temples of the glasses. Problems that arose with the first iteration of the glasses were loose thread connections between the fabric and the electronics. We also encountered difficulty securing the fabric patch and electronics to the hard plastic of the glasses.

Subsequent iterations of the example object focused on improving the connections between the LilyPad, its sensors and LED, and the glasses. We first laser cut cardboard bases onto which the LilyPad and its sensors could be attached by winding conductive thread through the holes in the electronics and then through holes in the cardboard cutouts. We connected the cardboard cutouts to each other by winding wire in a vertical orientation around the openings in the cutouts, giving the appearance of a "stack of electronics." The wires were color-coded to correspond to specific pins on the LilyPad and sensors. One concern with this prototype was the challenge that bending and twisting wires may pose to older adults.

5. FINDINGS

In the findings section we discuss the major themes that surfaced from our participatory design workshop as well as the sample objects we made and the development process of the toolkit.

5.1 Participatory Design

Several major themes emerged from the participatory design workshop such as adding lights to improve the aesthetics of crafts, enhancing the interactivity of crafted objects by adding lights along with other sensors, and using electronics to create customized household objects relating to health, security, and recreation.

Many participants were interested in using electronics to enhance the aesthetics of their existing creations, such as adding lights to shirts or quilts. Participants were also interested in using electronics to make their crafts more interactive and in addition to adding lights, would add other sensors or outputs. For example, one participant was interested in adding lights to her dog quilt as well as a motion activated voice box so it would bark when someone walked by. Another participant was interested in making a painting that would have motion activated lights. Several participants were interested in making lit creations that would only come on when it was dark.

In addition to enhancing the appearance of crafts they were currently creating, participants were interested in enhancing the functionality of everyday objects relating to health, security, and recreation. One participant thought of adding a heat sensor to a heating pad that would buzz if the temperature became too high for older people's sensitive skin. Several participants mentioned ideas about sensors that would detect motion and notify family members that their loved ones were up and about. Other kinds of sensors could indicate through lights or sound that one's blood sugar or oxygen levels had dropped. Another idea was putting a visual display on a box that would require the user to practice multiplication tables or play a game of X's and O's before the box would open.

5.2 Toolkit

Our toolkit contains a modified LilyPad Arduino, sensors, and LEDs. We included 3 outputs and 4 inputs.

Output	Input
LED	Light Sensor
Vibe Board	Temperature Sensor
Buzzer	Sound Sensor
	Distance Sensor

Additionally, we included USB Mini-B Cable and a coin cell battery holder. To modularize our toolkit and make integration into three-dimensional objects easier, each component had a soft base and hard base.

5.2.1 *Soft Textile Bases*

As a result of the prototyping process, our toolkit includes soft textile bases. These fabric bases make connecting components easier and allow the electronics to be easily integrated into fabrics (although the bases can also be used on hard surfaces). The textile bases are laser cut from cotton fabric and labeled with iron on fabric. Every fabric base has laser cut conductive fabric strips to allow the base to be used in a sewing machine. These strips of conductive fabric also allow the base to be ironed on to fabric items. The electronics components snap into the bases to allow for easy remove for washing and reuse in future projects. The fabric bases are color-coded with puffy paint to match the LilyPad components. The fabric bases are designed with different colors and shapes to differentiate outputs and inputs. The bases for outputs are teal and rectangular whereas the bases for inputs are grey and circular.

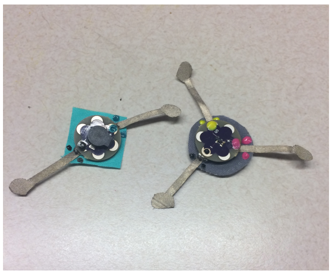

Figure 2: Soft Base for LilyPad with Snaps and Conductive Fabric

5.2.2 Hard Wooden Bases

In addition to the soft textile bases, we included hard wooden bases so that our toolkit could be used on hard surfaces. We included two types of hard wood bases, one that connects horizontally and another that stacks vertically.

The first base is designed to connect components horizontally. The bases were laser cut from balsa wood and components snap into the base. Every snap is conductively connected to a magnet. Wires with jewelry clasps on the end connect magnets of different components. The bases are designed with different shapes to differentiate between outputs, which are rectangular, and inputs, which are circular. The bases are engraved with the name of the component they hold. Puffy paint on the edges of the base corresponds with the color-coded LilyPad Components.

Figure 3: Hard Base for LilyPad with Snaps and Magnets

The second type of hard wooden base connects electrical components in a vertical orientation. Connections between the pins of the electronics are made by sliding magnets onto color-coded plastic magnet holders. The bases can effectively be "stacked" on top of each other by using these magnetic supports. Sensors can be interchanged between the bases by winding conductive thread through both the openings in the bases and the pin holes of the sensors.

6. DISCUSSION

6.1 Participatory Design

Participatory design workshops in HCI typically place a strong emphasis on generating ideas from participants and not necessarily the reciprocation of ideas between researchers and participants. For example, researchers have given participants the opportunity to experiment with technology [21] and organized prototyping sessions for the participants in which they design new electronic applications in the hopes of informing future design [9]. Our workshops not only demonstrated the functionality of small electronics to the participants, but also involved a "show-and-tell" session in which the participants taught us their craft. By actively involving ourselves and not just the participants in the learning process, we gained a better understanding of the participants' backgrounds, capabilities, and interests, helping us gear our toolkit towards their demographic. We found that giving participants hands-on experience with electronics resulted in the exchange of diverse and interesting ideas about electronic artifacts. Participants even demonstrated a desire to create technology-infused crafts on their own.

6.2 Exemplar Objects

We realized that placing a strong emphasis on modular design simplified the construction of our example objects. Adding snaps to the components allowed the parts to be reused in future projects while also eliminating the need to sew the difficult tabs into fabric. The conductive fabric allowed for the use of the sewing machine, making the process much faster. Similarly, using wire or magnets to connect LilyPad cutouts to sensors in a modular way allowed us to easily switch out the components and change their orientation on a hard surface. Future iterations of the "see-in-the-dark" glasses may entail extending the design of the cutouts to include other microcontrollers, such as Flora or the Arduino Nano. We could also explore ways in which the electrical connections could be artfully disguised. We extended this modularity to our toolkit to ensure that users can create a basic craft within a relatively short period of time.

6.3 Toolkit

Our toolkit is designed specifically for older adults because it is highly customizable, while still allowing those with little electronic knowledge to participate. We have modified the LilyPad Arduino [4] platform to make it easier to sew with conductive fabric strips and the connections are more obvious with a color coded system. Additionally, the toolkit has more guidance as it is accompanied by a written user manual catered for older adults as opposed to LilyPad's online guide pages. Components are can be connected with either copper tape or conductive thread. This allows for greater flexibility as the components do not require a specific platform or medium to be used, such as cloth or a hard surface. Previous maker kits were more abstracted and required a specific platform, such as MakerWear [12], which had magnetic connections to a specific platform, or littleBits [2], which had magnetic connections. Additionally, the toolkit can be used to create two-dimensional or three-dimensional products, and can be used to integrate electronics into preexisting household objects.

7. CONCLUSION

The conclusion will go here.

8. ACKNOWLEDGEMENTS

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