Making Well-Being: Exploring the Role of Makerspaces in Long-Term Care Facilities

Kayla Carucci
School of Information
University of Michigan
Ann Arbor, MI, USA
kcarucci@umich.edu

Kentaro Toyama
School of Information
University of Michigan
Ann Arbor, MI, USA
toyama@umich.edu

ABSTRACT

Fourth-age residents in long-term care facilities (LTCF) are known to suffer declines in well-being due to their advanced age and resulting loss of independence. Using an action research approach, we set up a makerspace in a New Jersey LTCF for eight weeks to see whether it could improve well-being for residents. Based on engaged observation over 280 hours and semi-structured interviews with participants, we find that people aged 80-99 years will spend (sometimes significant) time in a makerspace for the purposes of making and companionship; that makerspaces can contribute to both autonomy and well-being for older residents; and participants produced not only decorative art, but novel artifacts that solved real challenges in their daily lives. We situate these findings in the literature on art and activity therapy for fourth-age people, and make recommendations for makerspaces in long-term care facilities.

CCS CONCEPTS

• **Human-centered computing → Ethnographic studies**;

KEYWORDS

Maker Culture; Older Adults; Nursing Homes; Well-being

ACM Reference Format:
Kayla Carucci and Kentaro Toyama. 2019. Making Well-Being: Exploring the Role of Makerspaces in Long-Term Care Facilities. In *CHI Conference on Human Factors in Computing Systems Proceedings (CHI 2019), May 4–9, 2019, Glasgow, Scotland Uk.* ACM, New York, NY, USA, 12 pages. https://doi.org/10.1145/3290605.3300699

CHI 2019, May 4–9, 2019, Glasgow, Scotland Uk

ACM ISBN 978-1-4503-5970-2/19/05…$15.00
https://doi.org/10.1145/3290605.3300699

1 INTRODUCTION

Over the next three decades, the number of Americans aged 65 and over is expected to double, a fact attributable to the bump from the "baby boomers" born between 1946 and 1964 [10]. The youngest boomers will reach older adulthood around 2030, and some calculate a 75% increase in the number of older adults who will require care in assisted living residences, nursing homes, and skilled nursing facilities, collectively called "long term care facilities" (LTCF) [34][35].

LTCF residents are highly vulnerable to declines in well-being and sense of autonomy, as a result of decreased social interaction, physical activity, and intellectual stimulation [36] [11]. These issues can lead to depression, cognitive impairment, and chronic illness, and the problems are compounded for those 80 years and above—so-called *fourth-age* people who are experiencing a loss of independence due to an increasing feebleness or frailty.

Partly to combat these declines, many long-term care facilities feature painting classes, reading clubs, and other group activities for their residents. These activities have been shown to improve well-being [9][15][43][41], but they have a number of limitations. First, for the sake of administrative ease, such activities are highly structured—scheduled at specific hours of the week, focused on pre-determined projects, and sanitized of the even slightest risks. Second and related, the activities are typically led by LTCF staff with little input from the residents. Third, the activities tend to be based on activities thought to be appropriate for the residents; rarely are new ideas or technologies brought into the mix. In other words, the more common activities at LTCFs do not encourage resident initiative or the learning of contemporary skills.

In this paper, we report on the outcomes of a modern makerspace built within a LTCF with the express intent of engaging fourth-age residents. Online searches suggest this may be the first makerspace of its kind, and a literature search revealed no previous scholarship specifically about LTCF makerspaces despite a few related efforts. Our goal was

to see whether fourth-age residents would be interested in a makerspace, and if so, how it would affect the participants' well-being and sense of autonomy. Taking an active research approach, we operated the makerspace for 280 hours over eight weeks at a New Jersey LTCF, making changes along the way to increase use of the center and to cater to participant requests. Critical aspects of the makerspace were that it was unstructured in time (residents could come and go as they wished when the room was open), that the residents were expected to initiate their own projects, and that it included cutting-edge technologies such as a 3D printer and digital embroidering machines. We hypothesized that the emphasis on participant-led activity would contribute to their sense of autonomy as well as to their well-being. We were not sure whether the technology would appeal to residents.

Overall, we found that the makerspace was desired by a segment of the LTCF resident population, with users ranging in age from 81 to 99. These users had a range of physical challenges as would be expected for people of their age, but they were able to engage with equipment in the space meaningfully and productively. Typical makerspaces (that are not in LTCFs) are known to be frequented primarily by men [13][1][33], but it was women residents who used our space—only one man spent any time there, despite repeated attempts to engage male residents. Some of our most active users were interested not only in creating art and decorative artifacts, but in making objects that eased or solved everyday challenges they faced. We also found preliminary evidence that engagement with a makerspace could improve participants' sense of autonomy and well-being, though these possibilities require further investigation.

This work provides (1) an alternative to existing makerspace narratives that highlight younger, entrepreneurial usage; (2) a demonstration that people (and women in particular) aged 80-99 can engage deeply, meaningfully, and beneficially with makerspaces; (3) insights into the lived experience of fourth-age, long term care residents, interacting with a makerspace and to an extent aso otherwise; and (4) recommendations for makerspaces in long-term care facilities, which has both research and practical value.

2 RELATED WORK

For reasons that are unclear, the global maker movement appears to have overlooked fourth agers. Nevertheless, there is a significant body of research that is adjacent to our work. Below, we describe related work from gerontology, education, library science, and human computer interaction (HCI).

Aging and Autonomy

Aging brings obvious reductions in autonomy, but research suggests that those reductions are exacerbated by living in LTCFs [38][36].

Historian Peter Laslett divided the later years of adult life into the third and fourth ages [29]. Although Laslett did not assign numerical age ranges, the third age was described as "a phase of new freedom and opportunities after retirement", and the fourth age was a "period of final dependence, decrepitude and death" [36][29]. A study of Finnish 90-year-olds by Pirhonen et al. refined Laslett's definition by focusing on negotiated autonomy. The participants, some of whom retained highly autonomous lives, defined the fourth age by the loss of autonomous living capacity—e.g., being in a long-term care facility [36].

With respect to LTCFs, Quine and Morrell surveyed nearly 9,000 Australians over the age of 65 and found indeed that 14.4% saw LTCFs as a dramatic loss of independence [38]. Custers et al. found that over 20% of residents they surveyed felt that their basic needs of autonomy, relatedness, and competence [40] were not adequately met [11]. Relatedness was considered the most important need, but autonomy also figured highly, especially for residents with little to no cognitive impairment. Complaints included not being able to choose what clothes to wear, not being permitted to eat on their own, and not being able to decide when to do things (including "when to go to the toilet")[11]. All of this is to say that autonomy figures prominently among the reasons why some LTCF residents experience declines in well-being.

Creativity and Older Adult Learning

In the last decade, there have been multiple studies focusing on creativity in older adults; creativity is believed to peak around age 40, after which people experience a decrease in new idea generation [15][27]. However, creative activities like painting, poetry, or journalling can help maintain creativity, even as they also improve self-esteem, problem-solving ability, resilience, life satisfaction, sense of autonomy [15], and even basic health [9][15].

It is no surprise then that a range of organizations have focused on providing creative outlets for older adults. Public libraries, for example, are one such site about which much has been written. Sabo reviews this literature and reports that third agers are interested in gaining new knowledge through library programs, but that libraries tend not to offer programming specifically for older adults [42]. Sabo also notes that third agers seek out these lifelong learning opportunities because the desire intellectual stimulation and want to reap the benefits creativity provides, such as improved well-being and quality of life [42].

Closer to our interests, Seo et al. report on four female third-agers, who participated in an 8 week interactive art making course designed by the researchers. The participants were 65 years of age or older, with full cognitive functioning, and living independently. The interactive art course was structured into three units which built on one another,

starting with interactive sound painting, followed by light up cards, and ending with creating interactive soft objects. Each session featured "a short briefing on the topic, a Q&A period" and time to complete the projects with the help of research assistants [43]. The study found that by including simple circuitry with paper and fabric crafts, the older women were intrigued, and challenged to learn new ways of self-expression. Additionally, the course helped to create intergenerational connections, as all participants reported bonding with their children, as well as the younger research assistants, over these new and exciting crafts. Overall, the sessions were said to have "improved [the participants] daily lives by inspiring creativity and self-expression, fostering collaborations and intergenerational relationships" [43].

We build on this line of work by contributing the possibility that even older adults than those of Seo's work, can engage and benefit from creative activities, and that beyond directed activities, outright makerspaces stressing personal initiative deserve further exploration.

Makerspaces

Makerspaces—defined as "an open workshop with different tools and equipment where people can go independently to make something"—have been a growing interest over the last decade [45]. But while many workshops might fit into this definition, actual makerspaces tend to share additional traits; They generally feature machines that are big, expensive, or high-tech—lathes, laser cutters, and 3D printers. Makerspaces are increasingly common in public libraries and schools [16][14][46][8], but many are commercial organizations with paid staff and fee-paying members. Observers have noticed that mainstream maker culture is dominated by men [1][13][33].

Increasingly, makers—participants of the evergrowing Maker Movement—of all ages have experienced benefits first-hand via their high-tech creative pursuits, ultimately helping these people to "see [themselves] as confident, capable, and creative individuals" [12]. Although participants of makerspaces are most frequently young men of middle to high SES [1], there is no reason the aging population couldn't reap these rewards themself, from active participation in a makerspace.

Within the HCI community, makerspaces have been investigated in a number of ways; in the early 2010s, Leah Buechley began to challenge what making looks like—bringing soft, feminine fabrics to the table with the LilyPad Arduino [5] [6]. Buechley also began to push back against the idea that computing, and makerspaces are a "boy's club" [5] [6], and this critique was furthered by [39][18] in the mid 2010s. Around the same time, Hurst and Tobias, explored how teaching people with disabilities to use digital fabrication tools could empower the individual to make customized assistive technology; not only was this cost saving, but it allowed for the individual to modify their technologies at a later date, if their needs changed [25]. Following this work, Hurst and Kane set began to make digital fabrication tools more accessible, once again empowering people with disabilities [24].

Jeffrey Bardzell, Shaowen Bardzell, and Austin Toombs examined the fluidity of materials, such as wire or boxes, as ad hoc tools makers repurposed in order to fulfill an immediate need for an act of creation [2]. Meanwhile, Lindtner, Hertz, and Dourish explored makerspaces as "emerging sites of innovation" in Shenzhen, China which brought about "new models of manufacturing and entrepreneurship" [31]. Since then, makerspaces as models for self-efficacy [8], and sites of entrepreneurship have persisted as a primary research focuses in HCI [23]. Most recently, there has been a growing critique of maker culture, who participates in it [37], and how researchers, social scientists, and policy makers can support makers [30][3][19].

Several characteristics of contemporary makerspaces can be potentially attractive for older adults. One emphasized by Make Magazine founder Dale Dougherty in [12], is that maker culture presents a unique opportunity for intergenerational knowledge sharing. The open, collaborative environment of makerspaces allows for cross-generational interaction. Makerspaces also allow for free expression and autonomy without the constraints of narrow guidance or instruction: Makers choose "what to work on, when to work on it, and whether and how they want to continue" [44]. Makerspaces also have great community-building potential, with some studies demonstrating reconciliation across groups in conflict [48].

The high-tech focus of makerspaces might also help bridge generational gaps that fourth agers might feel with their younger family members [43]. Finally, there is nascent work relevant to our goals, where vulnerable groups of men, such as recent retirees or war veterans, are exposed to makerspaces to overcome loneliness, address mental health issues, and improve overall well-being [48]. Despite the great potential of makerspaces, however, we have found no formally documented instances to date of a makerspace being built in an LTCF to serve its fourth-age residents.

3 STUDY DESIGN

We applied an action research approach to this study; over eight weeks between June and August, 2018, a long term care facility located in suburban New Jersey provided us space to construct and supervise a makerspace for their residents.

Prior to the study, we held an interest meeting with residents to inquire about their current roster of activities, and determine what areas they felt were lacking. We then presented a variety of low- to high-tech resources and potential projects. Based on this meeting, equipment was purchased to match what the residents most expressed interest in. During

the study, more equipment was purchased to meet high demand for the 3D printer, and iPads. This project was funded by small grants totalling $5,000 from our university. We also borrowed equipment from personal contacts for the study. Therefore, the residents did not incur any expenses as a result of this study. All non-university owned equipment, replacement parts and extra materials were donated to the facility.

The makerspace was stocked with both high- and low-tech equipment, and marketed internally as a trial hybrid traditional and digital creative arts program in which residents pre-approved by the facility (to ensure health and cognitive requirements) could participate. The makerspace was dubbed "Creations with Kayla" by the facility staff, and it was open Tuesday-Saturday, 7 hours a day. Residents were allowed to come and go at their leisure. Over the eight weeks, fourteen residents interacted to varying degrees with the makerspace.

The first author served as researcher, supervisor, peer, and guide (henceforth, referred to as "the guide") for all 280 hours that the makerspace was open. The guide encouraged residents to propose their own projects and pursue them in a self-directed manner, however the guide was always available to give demos, answer questions, troubleshoot errors, brainstorm ideas, and even collaborate in making.

We conducted approximately 250 hours of participant observation, had around 200 informal interactions, three semi-structured interviews, and a survey, all with the goal of answering the following research questions: First, how do fourth age residents respond to a lightly supervised makerspace, especially as compared with more structured LTCF activities? Second, how does self-directed activity in a makerspace affect LTCF participants, particularly with respect to their perceived agency and well-being? Third, how can a LTCF best operate and support a makerspace that caters to its residents?

Community Partner

Our community partner is a highly rated, not-for-profit Christian senior living community, receiving 5 out of 5 stars based on the Centers for Medicare & Medicaid Services' Quality Rating System, which uses a range of measures to assess how well the facility cares for its residents[17]. The facility is composed of two separate wings to accommodate residents with a wide range of ability; one wing is for assisted living *(AL)* residents who require lower levels of care, and the other is for residents who require full long term skilled nursing care *(SC)*. At capacity, the facility is capable of accommodating 54 residents in assisted living, and 108 residents in long term skilled nursing care. On average, the gender ratio is 15% male to 85% female, and the minimum age requirement is 60 years old—although currently, the youngest resident is 70 years old.

The research project was borne out of an expressed need by the facility, as much as for research motivations. The facility as a whole was deeply committed to the makerspace, because in the half year period prior to the study, residents expressed dissatisfaction with the roster of activities, citing boredom and lack of challenge. Prior to the study, our community partner had a full roster of activities, including: a painting class offered 2x/week, a crafting class 2x/week, and a biweekly art history course. 11 of our 14 participants were actively involved in these pursuits 2+ times per week. The facility also has a multipurpose room and four desktop computers for free use by the residents. The latter resources were largely unused prior to the study. The import of this is that the makerspace differed from other offerings in neither being scheduled activities, nor just a freely accessible bank of computers. Given these circumstances, we deemed the facility as an ideal community partner for this study.

Finally, we note that on top of the many favorable circumstances described above, the first author had pre-existing relationships with administrators and staff from previous volunteer work. All of this likely facilitated the project to a great degree, a fact which should be taken into account when our findings below are applied to other similar contexts.

Participants

There were several sets of constraints on who could participate in the makerspace. One was requested by the facility's Director of Nursing and Director of Wellness, who required participants to be in relatively good health and cognitively alert and oriented; some mild memory impairment was allowed. They also required that participants had moderate to fine motor skills, so as to be able to use the equipment safely. Another set was imposed by us for research reasons: We sought participants 80 years old and over (roughly corresponding to Laslett's fourth age), and who were interested in creative activities. Initially, we all (the facility and researchers) believed that only AL residents (who had greater physical and cognitive capacity) would qualify, but over time it became apparent that there was both interest and ability to engage among the SC residents.

Based on the above, about 60 people (out of 134 at the facility) were deemed eligible to participate. To recruit among them, we used a combination of recommendations from the facility staff and nurses' aids; flyers; equipment demonstrations; and snowballing. Ultimately, fourteen participants engaged with the makerspace in some form, though their involvement varied considerably. Of these fourteen, three participants engaged on a daily basis, and additional two on a semi-regular basis. There were also two participants who

Name	Age	M/F	Status	Notes
Clara	81	F	AL	Curious. Not interested in creative work. Visited daily to talk with guide.
Esther	84	F	AL	Early adopter. Semi-regular participant. Keen interest in 3D printing.
Ruth	84	F	AL	Started in Week 6. Thoughtful. Purposeful. Wishes she participated earlier.
Edith	84	F	AL	Came in with Winnie. Did not return when SC residents started to come.
Juanita	87	F	SC	Daily participant, recovering from severe stroke. Pragmatic. Fiercely determined.
Winnie	87	F	AL	Well-liked. Bossy. Came Week 1. Didn't return when SC residents joined.
William	88	M	AL	Visited in Week 1. Did not return because he's "too old to do all of that".
Marcia	89	F	AL	Came with Ruth. Interest in 3D printer pen. Didn't return; time constraints.
Kitty	92	F	AL	"The Inspector". Constantly observed. Never participated. Confirmed kleptomaniac.
Mabel	92	F	AL	Came in with Winnie. Showed interest, but did not return—reason unknown.
Gigi	92	F	SC	Early participant; spent 6-7 hours daily in space. Became very attached to guide.
Betty	96	F	SC	Curious. Strong willed. Excited to participate. Did not return after facility staff violated her autonomy and personal space, by moving her wheelchair without permission.
Rosalind	98	F	SC	Cheerful. Charismatic. Daily participant. Loves to converse with others.
Josie	99	F	AL	Serious. Quite. Displayed an interest when others brought her to space.

Table 1: A brief overview of the study participants.

came to the makerspace exclusively for companionship. All names used in this paper are pseudonyms.

Data Collection and Analysis

The main research paradigm we used was ethnographic action research, in which qualitative research methods are combined with a plan-act-reflect cycle to iteratively improve a program's outcomes [21]. The action research cycle was applied continuously through the eight weeks by the guide, who was present for all 280 hours of the makerspace's trial operation, and kept daily handwritten notes totalling 160 pages. These field notes contained descriptions of the participants; descriptions of participant requests for instruction or guidance; collaboration and social interactions between participants; descriptions of equipment and materials; descriptions of projects as undertaken by users; the participants use of makerspace equipment; and finally, the guide's raw reactions of ongoing events.

As an embedded participant in the action, much of the data from the study emerged from informal interactions with makerspace participants, non-participant the facility residents, the facility staff and leadership, and visiting family members of the residents—we estimate a total of about 200 such interactions. In addition, we conducted three formal semi-structured interviews with the three most devoted users of the makerspace—Gigi, Rosalind, and Juanita (we use pseudonyms throughout). The interview protocol was developed based on the related literature, and focused on prior creative art experiences, maker preferences, thoughts regarding the high tech forms of making, feelings about the value of the makerspace, and potential contributions to sense of autonomy or well-being. Each interview lasted approximately 45-60 minutes, and was conducted around the midpoint of the trial. The same three users were also asked to complete surveys twice—once near the beginning of their involvement, and once on the last day of the trial. These surveys containing instruments for well-being and autonomy adapted from the Rand 36 Item Short Form survey [22], and the Basic Psychological Need Satisfaction and Frustration Scale [7]. 240 hours of the makerspace were video-recorded, 100 photographs were taken, and interviews were audio-recorded, all with the participants' permission; the interviews were professionally transcribed.

Thematic analysis was applied to the transcripts and field notes, with all textual documentation read through multiple times for repeating themes and patterns. As key themes were identified, the transcripts and notes were reviewed again for additional content that might be relevant to each theme. The analysis process begun around Week 3 of the trial, and it continued through the writing of the paper.

Timeline

Prior to program start: Held a meeting with residents to determine their interests, and make purchasing decisions.
Week 1: Set up in initial makerspace off of the AL wing, with a Makerbot Replicator 2, Brother Digital Embroidery machine, Squishy Circuts, and Paper circuts. 3D printing was an immediate hit.
Week 2: Relocated to a bigger, but less central, room due to high levels of interest. 3D printing continued to draw the most attention. Participants expressed greater interest in digital embroidery.
Week 3: SC residents began to participate, causing some AL residents to lose interest. We purchased an XYZ 3D printer,

and a Brother digital sewing machine.
Week 4: Relocated to final, most central, and most popular location; temporarily shared with the facility activities staff. Interviews and surveys occurred.
Week 5: The "End of Summer Craft Sale" was conceived by participants as a motivation for projects. Activities staff scheduled an event conflicting with the makerspace hours; a facility staff member wheeled makerspace participants out of the room—without their permission—to make space for their event. One participant, Betty, was incredibly offended and ceased participation in the study.
Week 6: The facility activities staff moved to another space, leaving our makerspace the only occupant. Nurses' aids recommended new residents for the program.
Week 7: Regular participants expressed sadness and frustration that the makerspace trial would be over soon.
Week 8: Last week of program; surveys were given again; the End of Summer Craft Sale was held.

4 FINDINGS AND ANALYSIS

In the hopes of conveying a real sense for our participants in a limited space while also identifying salient trends, and to honor the ethnographic emphasis of action research, we break with the dominant style of qualitative CHI reporting: Instead of starting with a clinical set of facts and then proceeding to a separate discussion of their interpretation, we present five of our most prominent interpreted findings below using ethnographic "thick description" [20]–the subsequent sections are broadly organized in two categories: how participants used the makerspace, and what participants seemed to gain from making.

Residents felt empowered by the makerspace to solve everyday problems.

We confess that going into this project, we were given to some stereotyped notions of fourth-age people – that they would tend to be passive; and that the reportedly male-dominated maker culture would not readily translate, especially for women. Many of our colleagues shared these views – those who reviewed our research proposal asked if we had an alternative plan in case 80-year-olds did not engage with the makerspace.

To our delight, however, our participants blew these stereotypes away. Not only did residents aged 81-99 engage with the makerspace, the most active participants used the makerspace in exactly the way that maker culture encourages – to solve their own daily challenges. For example, Esther, one of the first participants in the program, was driven by a sense of pragmatism from the outset. In week two, she strode into the makerspace, loudly proclaiming: *"I want to 3D print a blue vase!"* because her window sill needed *"a splash of color"*. Although her print failed due to a jam in the extruder, Esther

Figure 1: (Clockwise) Gigi works on a sculpture using a 3D printer pen; Esther's failed print inspires a collection; Juanita makes buttons for the craft fair. ©Kayla Carucci

was excited by the unfinished print, the size of a small ring bowl, and proudly displayed it in her room, since her main goal had been to add a pop of color.

Another early adopter of the program—Gigi—worked on a series of problem-solving projects. In Week 3, she confided to the guide that she believed her new sweater had been stolen. *"The aid told me she took it down to the wash, but I didn't get it back and now they're saying they can't find it!"* Gigi expressed deep frustration, because it was not the first time an item of hers had gone missing. After being uncharacteristically quiet for some time, Gigi paused to ask the guide, *"Could we...? I mean, would it be possible to... to put my name on a different sweater?"* while gesturing towards the digital embroidery machine. The next day Gigi returned with two older sweaters. With a little assistance from the guide, she tested the lettering on scrap fabric and after finding the right font, Gigi was ready to jump in. Selecting a gold thread, Gigi embroidered her initials on a white sweater. Pleased with the result, she picked a pink embroidery thread, and repeated the process on a black sweater by herself.

After successfully embroidering her sweaters, Gigi then discussed another problem with the guide: her tote bag was too large to hang from the back of her wheelchair, and thus frequently became tangled in the spokes. When asked if she wanted to make a tote bag customized for her wheelchair measurements, Gigi was hesitant to agree. She seemed unsure of the level difficulty of such a project. Eventually, her

desire for a bag the appropriate size won out. As it was her first time using the digital sewing machine, the seams and edges were rather sloppy. She then used an accent color to hide the mistakes. In the same color, Gigi added a single strap so it could hang across both handles of the wheelchair.

Then, in the last week of the program, Gigi brought in two green pillow shams with rips in the seams. She said: *"I bought these, oh I don't know—maybe nine months ago. When the aid went to put them on, she found the holes and asked me what I wanted to do. I was so angry, because what could I do now? I couldn't take them back, and I told her to just put them in the drawer"*. It occurred to Gigi that she could fix the shams herself, and she had the seams resewn in a matter of minutes.

Other residents were inspired by Gigi and Esther's projects. Betty, 96 years old, was hesitant about participating in the program, but after warming up to the idea, she asked if she could 3D-print a necklace. After finding the pattern for a simple heart pendant, Betty confessed that she stopped wearing necklaces and fine jewelry a long time ago, due to the tubes for her oxygen tank. Removing the necklace for examinations complicated the procedure, and Betty worried a necklace would become damaged or lost in the process. However, a 3D-printed necklace was the ideal solution: *"When it's done, I can string it with a ribbon, and then if it breaks, then I'll come make another one!"*

Similarly, Josie found inspiration one afternoon, when she observed Juanita and Gigi making bracelets to sell at the craft sale. At first hesitant, Josie lined up quartz and mother of pearl beads to thread. Modelling her bracelet, Josie confided, *"I don't wear a wrist watch anymore—I don't even know where it is... but now I have a bracelet to accessorize with!"*

Residents used the makerspace to create unique, personalized gifts for loved ones.

Two weeks after attempting her own vase, Esther returned to make another one for a friend who had recently been sent out to the hospital. *"Whenever she gets back, she'll have to go to [Skilled Care] for rehab, and she won't have many of her personal items—those will be in her apartment."* Wanting her friend to have something lively for the temporary room, Esther planned to bring wildflowers in a 3D printed vase.

In another instance, Esther stopped into the makerspace, and said to the guide: *"I want to make one of those light-up cards for my cousin, could you help me with that?"* She believed that a chibitronics card [37] would be more special than sending one from the store—particularly because the pair often exchanged handwritten notes. Although the card took multiple sessions to complete, Esther was quite happy with the finished product.

Similarly, when Gigi was unable to go shopping for a 50th wedding anniversary, Gigi made a card that was more heartfelt than one from the store. She created a special note using cardstock and bookmaking supplies available in the makerspace.

Gigi also wanted to embroider an apron for her daughter-in-law's birthday, but had trouble deciding what phrase she should stitch; she had chosen an apron, because *"Gloria's children gave her one for Mother's Day with 'World's Best Cookie Maker' written on it, but she makes her cookies from the dough you buy in store!"*, which the daughter-in-law refused to wear. *"She's actually a very good cook, and I guess, well I want her to know that I appreciate all the things she does for me."* After debating phrases for a few days, Gigi settled on the phrase "Chef Gloria's Kitchen" written in cursive.

Ruth first came to the makerspace in Week 5 to make a scrapbook for her great grandson. *"We're going to celebrate Tommy's first birthday in a few weeks,"* and Ruth wanted to give him something special—which was *"a difficult task for the child that already has everything."* She thought a scrapbook would be perfect, because *"Tommy's parents can use it for all of his firsts, and then one day he can look through it, and have a document of the first year of his life."*

We see here again, that our participants engaged with the makerspace in very much the way that maker culture encourages [12]: One aspect of the do-it-yourself ethos of makerspaces is that one's creations are not mass-produced consumer products, but unique artifacts imbued with the maker's own sensibilities. In the cases above, our participants appeared to come to a similar conclusion, even when they initially came to making as a last-resort alternative to closed-off consumer choices.

Residents viewed the makerspace as a place to seek companionship, likely contributing to their well-being.

Many residents were not active makers throughout the program, however, they did visit the makerspace for informal social gatherings to talk about daily life, and the creative projects being worked on. Our notes are sprinkled with off-hand comments and observations about the contributions of the makerspace to participants and visitors' social life.

Rosalind came to the makerspace 3-4 days a week to "continue working on her project" – at times knitting, at times creating a digital painting. But, she spent most of the time chatting. Rosalind would inform everyone about goings-on at the facility, generally unsolicited. Over five weeks, she completed two paintings, one candle, and made small progress on a knitting project. Her cheery disposition made all the residents feel at ease in the makerspace.

Esther was another resident who sought companionship. During her daily walking routine, she would pass by, pausing to observe the room; If people were quietly working, Esther

Figure 2: Various projects the residents completed during the eight week study, including 3D printing, book making, jewelry making, and digital embroidery. ©Kayla Carucci

would nod hello before continuing down the hallway. However, if people were casually chatting, she would come in and enthusiastically join the conversation. Esther seemed to enjoy taking a short reprieve from her scheduled 45 minute walks, in order to socialize with the other residents.

Kitty was also a frequent presence in the makerspace, but unlike Rosalind and Esther, she did not engage in conversation. Kitty became a frequent visitor beginning Week 4, when the makerspace relocated to its final, central location. Three or four times a day, Kitty would come in, circle the room, and observe participants working on projects. Nurse's aids expressed considerable surprise that Kitty took an interest in the makerspace at all, describing her as someone who is *"relatively withdrawn,"* who *"participates in very few activities,"* and who *"spends the majority of her time in her room."* Our impression was that Kitty did not wish to engage with makers or making, but that she still valued the presence of other human beings. The makerspace offered her a space for this liminal form of companionship by providing a focus of attention (the projects) that allowed her to be with other people without speaking.

Likewise, another resident, Juanita, openly admitted to not socializing with others at the facility, due to different lived experiences: *"Women my age mostly have been married... So, I don't have the experience of caring for a husband, children, et cetera."* Juanita had one friend, Rosalind, who shared a deep love of travelling. The two were often found together in the makerspace. Over time, Juanita opened up to the guide and other participants.

A number of participants expressed their appreciation for the companionship in the makerspace explicitly. On Gigi's first visit to the makerspace, she asked the guide, *"Can I bring my knitting here, and sit with you tomorrow? There use to be a group, but these old lazies stopped going—and I like having someone to just sit and knit and talk with."* That was the beginning of Gigi's becoming a regular makerspace participant. Even when she wasn't actively making, Gigi would talk with others in the room while they worked. Over time, Gigi grew very attached to the guide, referring to her as *"my adopted daughter"*; in an interview, she said: *"I spend some time, as much as I can, with [her]. And I enjoy her projects and I feel like I'm getting younger watching the things that she does. And I just enjoy being with her."*

Clara was another participant who developed a close relationship with the guide. During Week 1, Clara made a card with a single LED and exposed copper tape; it said, "Having fun in my old age! Miss you. Love, Mom." Although she was curious about the makerspace, creative activities did not really appeal to Clara, so she did not return until Week 4. But then, she began to visit daily to read the New York Times before dinner. Clara would inquire about the projects while skimming the front page; then she would begin a conversation about an article, while continuing to peruse the paper. Clara took a particular interest in the guide's personal life and education. On the last day of the trial, Clara said that she would miss having the guide around, and sent her off with a hug: *"Thank you for showing us old people what's going on out there in the real world."*

Making could help residents recall old memories, often accompanied by expressions of delight.

In August, Rosalind was scrolling through coloring books, unsure of what to paint next. After rejecting many images, she selected a German Shepherd: *"This one! Oh—this looks just like a dog I had when I was younger, just like him!"*. She completed the painting over four sessions: The first day, Rosalind was hyper-focused, searching the pallet for specific colors and shades, ignoring everyone else—a behavior highly unusual for her. When she next visited, Rosalind tested various brushes and strokes with the Apple pencil, attempting to recreate her dog's fur; repeating her earlier statement, Rosalind added that his name had been Spike. Again, she seemed pensive, caught in her own world. The third day brought the revelation that Rosalind was sharing these bits of information as she remembered them; she spent 45 minutes testing shades of blue before finding *"the correct shade for the eyes."* During this time, she recounted the story of when she wanted to submit Spike to competitions, but ultimately did not because the *"dog trainer was cruel and I wanted him*

to have a happy life, just being a dog." It was not precisely that Rosalind had forgotten about Spike, but working on the painting gave her the pleasure of reremembering, and sharing, happy memories.

In Week 7, we observed Juanita—who suffered a severe stroke a year before—making buttons and magnets to sell for the craft fair. She had selected a pattern of antique bicycles, but could not describe why she had chosen it. As she cut circles with the hole puncher, Juanita began to talk about a friend who bicycled across Germany with her. Continuing with the pins, Juanita recounted different cross country trips they had taken in their younger days. One aid who had been listening, said: *"I've known you since you got here, and I didn't know that—that you were an avid cyclist!"* Juanita replied, *"I had completely forgotten until now, only I was looking, and kept coming back to these bicycles."*

Despite her protests about having severe arthritis, on her first visit, Betty had been wheeled into the makerspace by her daughter who requested an easy project. She was presented with a Makey Makey kit [32] with conductive play dough, so Betty could play piano on the computer using the large soft keys. Betty sat aloof and unresponsive as her daughter played the tune Do-Re-Mi, asking: *"Do you remember this mom?"* To which Betty replied, *"I don't know!"* After a few more unsuccessful repetitions, the guide prompted Betty: *"Do you remember this? Did you use to play piano?"* while guiding her hands through Do-Re-Mi. This caused her face to light up, as she replied, *"No! But I made my children take lessons, and they played this constantly!"*

Among researchers who study aging and memory loss, there is broad consensus that one of the main consequences of memory loss is loss of identity, and that the loss of identity detracts from well-being [26][4]. The events we observed suggest the potential for making as a site of remembering, which in turn might contribute in small ways to well-being. The eureka moments we witnessed were almost always accompanied by expressions of joy or delight.

Making can improve fourth-agers' sense of agency and control.

It was with respect to issues of choice, control, and agency, that our participants were most explicit and vocal about what they gained from the makerspace.

Juanita said that creative projects made her feel in control and carefree. After her stroke, Juanita's life was radically different—she had suffered from retrograde amnesia, and had impaired communication due to expressive aphasia. However, she said, *"I can maintain the drawing. As you realized I am doing creative things. So I can be me... it makes me feel in control."* Her explanation matched a fierce determination we previously observed in her. In one instance, when Juanita struggled to insert a metal clasp on a pin, the guide offered help, to which she replied, *"I need to do one myself. I just need to know that I can do this."*

Similarly, Rosalind, who did not have full range of motion in her dominant hand due to muscle contractures, explained her love of creative projects: *"Well, I like to see myself accomplish something and see how it comes out... Since my hand got like this, I have to—I can't do a lot of things I used to do. So, what I'm doing to keep myself busy and to try to get it back, I've been making [knitting] triangles."*

After a few visits, Betty told a the facility staff member, *"I have arthritis and can't write or do much with my hands, but I can design something on the 3D printer and watch it print. I can finally do crafts again!"*

Apart from overt expressions of regained agency, we also observed that some participants grew more assertive through making. Working on creative projects seemed to lead to defending their own decisions more forcefully, in an environment that otherwise tended to make choices on their behalf. In Week 5, Gigi was told by the guide that a painting she had announced to be finished still had a few unpainted white patches. Gigi looked at the guide sourly, and said: *"No! It's done. If it's white it's because it's suppose to be white."* Later that week, the guide encouraged Josie to add more colors to a bracelet she was making, noting that she would run out of beads soon. She replied, *"I don't want to add any other colors—white goes with everything. This is Josie's bracelet, Josie's style."* She went on to contemplate how to best solve her bead shortage problem. It was not clear whether the participants themselves noticed this greater assertiveness in themselves, but it was noticeable to us. It is frequently lamented that as a society, we write off our oldest members [28], and this tendency extends to the HCI community. Despite the significant literature on technology and aging [43][48][41], most of it deals with third-age people, not those who have exceeded developed-world life expectancies. Against this backdrop, it may seem quixotic to introduce fourth-agers to an idealistic, cutting-edge movement such as the maker movement. Yet, our study demonstrates that people in their 90s are not only curious about making, but eager and willing to engage and to do so intensively. They upend stereotypes about old-age passivity and physical or cognitive incapacity [36]; for its part, a makerspace seems to have the ability to empower even the oldest LTCF residents by encouraging self-driven exploration and creation, with possible contributions to well-being.

As to how this might happen, we speculate that makerspaces offer an opportunity to exercise each of Ryan & Deci's [40] three pillars of well-being: autonomy, competence, and relatedness. Our findings above showcase multiple instances in which participants consciously or unconsciously expressed a desire for these qualities, and then exercised them in the makerspace.

We do not claim that makerspaces definitively mitigate problems of autonomy and well-being for fourth-age LTCF residents, but our exploration generated sufficient evidence to justify further investigation of this unexplored frontier of research. Like Hurst and Tobias [25] and Taylor et al. [48], we believe in the potential of making as a lever for social impact, and we expand that view to an overlooked generation. Like Seo et al. [43], we believe interactive high-tech creation can benefit older adults, but we encourage extending explorations to those 80 and up, and with less structured activities. Like Sabeti [41], we believe that older adults can and want to continue to learn, and we suspect that many of the values of the maker movement—community, self-initiative, physical creation, peer-learning, and unstructured exploration—are ideally suited to fourth agers.

Yet, not all of our findings are positive. Among the surprises was the lack of interest from men, despite frequent efforts on our part to recruit them. Thirteen of the fourteen participants in this study were female, and the one man did not return after his initial visit. This is particularly noteworthy, given the great gender imbalance other makerspaces are believed to have, but skewing toward men [13].

Implications for LTCFs

Below, we use our own findings to make recommendations for LTCF-based makerspaces. While these recommendations are offered in a direct way for conciseness, we caution that these are merely suggestions based on a single trial at a particular New Jersey LTCF that was predisposed to the makerspace. We hope our suggestions serve as a good starting point for planning future LTCF makerspaces, but the recommendations are likely to require adaptation for differing context.

Hire new staff whose sole responsibility is to the makerspace. The reasons are several: Research shows that volunteers and temporary staff in LTCFs are more likely to encourage self-maintenance and autonomous behavior in residents [47]. Interest in making is not necessarily readily found among regular LTCF staff. Finally, residents may feel more comfortable with a person who is less involved with other aspects of the LTCF.

Equip the makerspace with a range of low- and high-tech tools. Many residents in the study were initially weary of newer technology, such as the computerized sewing or embroidery machines. Some residents even refused to engage with the space because of feelings that they were "too old" for it. By offering and openly demonstrating lower tech equipment, the makerspace can appeal to a wider range of residents.

Ensure staff training to support self-directed learning, with attention to the balance between providing guidance and autonomy. For example, Juanita struggled with fine beads and needles, but she insisted on completing these tasks on her own, despite it taking an unusually long amount of time. If the guide had stepped in and insisted on helping, Juanita would have lost the sense of agency.

Ensure staff who are personable, willing to learn, and prepared to troubleshoot problems as they arise. The guide was not intimately familiar with all of the equipment prior to this study, but was excited to learn new tools and willing to troubleshoot problems with the equipment.

Provide a dedicated space central to residents, and allow unstructured access to the space whenever possible. By allowing unstructured access to a relatively unmonitored space, residents feel comfortable engaging at their own pace, with their own style, and on their own initiative.

Implementation need not be all-or-nothing, and some of the ideas could be implemented partially or piecemeal. For example, even without high-tech making equipment, a space could be dedicated to arts and crafts without structured programming.

Study Limitations

This study is not without its limitations. Among the key limitations was that while 14 participants engaged with the makerspace in some form, retention was low; only three participants made things on a regular basis, and none were men. While we drew lessons from all participants, we acknowledge more research is needed to verify our findings, especially where they involve actual making. Another limitation was the favorable conditions of the LTCF we worked with. It was well-resourced, and there was encouragement from the center leadership. We expect that conditions at other LTCFs will not necessarily be as conducive.

5 CONCLUSION

Using an action research approach, we set up a makerspace in a LTCF to see whether it could improve the well-being of its residents. Based on engaged observation and semi-structured interviews with participants, we collected qualitative data which demonstrates the potential benefits of a makerspace housed in a LTCF. Our results build on research about the value of art and activity for fourth-age people, and highlight instances in which an unstructured makerspace contributes to critical pillars of well-being such as competence, autonomy, relatedness, and identity. Our work is preliminary, however, and we encourage further work to understand the vast social-cultural potential of these unique spaces, especially for the understudied fourth-age population.

REFERENCES

[1] Karlin Associates. 2012. *Maker Market Study.* Technical Report. Make Media and Intel. https://cdn.makezine.com/make/sales/Maker-Market-Study.pdf

[2] Jeffrey Bardzell, Shaowen Bardzell, and Austin Toombs. 2014. "Now That's Definitely a Proper Hack": Self-made Tools in Hackerspaces. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '14)*. ACM, New York, NY, USA, 473–476. https://doi.org/10.1145/2556288.2557221

[3] Shaowen Bardzell, Jeffrey Bardzell, and Sarah Ng. 2017. Supporting Cultures of Making: Technology, Policy, Visions, and Myths. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. ACM, New York, NY, USA, 6523–6535. https://doi.org/10.1145/3025453.3025975

[4] Renee L. Beard. 2004. In their voices: Identity preservation and experiences of Alzheimer's disease. *Journal of Aging Studies* 18, 4 (2004), 415 – 428. https://doi.org/10.1016/j.jaging.2004.06.005

[5] Leah Buechley and Benjamin Mako Hill. 2010. LilyPad in the wild: how hardware's long tail is supporting new engineering and design communities. In *Conference on Designing Interactive Systems*.

[6] Leah Buechley and Hannah Perner-Wilson. 2012. Crafting technology: Reimagining the processes, materials, and cultures of electronics. *ACM Transactions on Computer-Human Interaction* 19, 3 (10 2012), 1–21. https://doi.org/10.1145/2362364.2362369

[7] Vansteenkiste M. Beyers W. Boone L. Deci E. L. Duriez B. Lens W. Matos L. Mouratidis A. Ryan R. M. Sheldon K. M. Soenens B. Van Petegem S. & Van der Kaap-Deeder J. Verstuyf J Chen, B. 2015. Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion* 39 (2015), 216–236.

[8] Sharon Lynn Chu, Rebecca Schlegel, Francis Quek, Andrew Christy, and Kaiyuan Chen. 2017. 'I Make, Therefore I Am': The Effects of Curriculum-Aligned Making on Children's Self-Identity. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. ACM, New York, NY, USA, 109–120. https://doi.org/10.1145/3025453.3025458

[9] Gene D Cohen. 2007. *The mature mind: the positive power of the aging brain*. Basic Books, New York.

[10] Sandra L Colby and Jennifer M Ortman. 2014. *The Baby Boom Cohort in the United States: 2012 to 2060*. Technical Report P25-1141. U.S. Census Bureau. 16 pages. https://www.census.gov/prod/2014pubs/p25-1141.pdf

[11] Annette F J Custers, Gerben J Westerhof, Yolande Kuin, and Marianne Riksen-Walraven. 2010. Need fulfillment in caring relationships: Its relation with well-being of residents in somatic nursing homes. *Aging & Mental Health* 14, 6 (8 2010), 731–739. https://doi.org/10.1080/13607861003713133

[12] Dale Dougherty. 2016. *Free to make: how the maker movement is changing our schools, our jobs, and our minds*. North Atlantic Books, Berkeley, California.

[13] SUSAN FAULKNER and ANNE MCCLARD. 2014. Making Change: Can Ethnographic Research about Women Makers Change the Future of Computing? *Ethnographic Praxis in Industry Conference Proceedings* 1 (2014), 187–198. https://doi.org/10.1111/1559-8918.01026 arXiv:https://anthrosource.onlinelibrary.wiley.com/doi/pdf/10.1111/1559-8918.01026

[14] Daniel Fitton, Janet C. Read, and John Dempsey. 2015. Exploring Children's Designs for Maker Technologies. In *Proceedings of the 14th International Conference on Interaction Design and Children (IDC '15)*. ACM, New York, NY, USA, 379–382. https://doi.org/10.1145/2771839.2771921

[15] Meredith Flood and Kenneth D Phillips. 2007. Creativity in older adults: a plethora of possibilities. *Issues in Mental Health Nursing* 28, 4 (4 2007), 389–411. https://doi.org/10.1080/01612840701252956

[16] Kristin Fontichiaro. 2016. Sustaining a Makerspace. *Teacher Librarian* 43, 4 (02 2016), 39–41. http://proxy.lib.umich.edu/login?url=https://search-proquest-com.proxy.lib.umich.edu/docview/1774309533?accountid=14667 Copyright - Copyright E L Kurdyla Publishing LLC Feb 2016; Document feature - ; Last updated - 2017-11-23.

[17] U.S. Centers for Medicare and Medicaid Services. 2018. Five-Star Quality Rating System. Website. (8 2018). https://www.cms.gov/medicare/provider-enrollment-and-certification/certificationandcomplianc/fsqrs.html

[18] Sarah Fox, Rachel Rose Ulgado, and Daniela Rosner. 2015. Hacking Culture, Not Devices: Access and Recognition in Feminist Hackerspaces. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW '15)*. ACM, New York, NY, USA, 56–68. https://doi.org/10.1145/2675133.2675223

[19] Guo Freeman, Shaowen Bardzell, and Jeffrey Bardzell. 2018. Bottom-Up Imaginaries: The Cultural-Technical Practice of Inventing Regional Advantage Through IT R&D. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, Article 325, 11 pages. https://doi.org/10.1145/3173574.3173899

[20] Clifford Geertz. 2008. Thick description: Toward an interpretive theory of culture. In *The Cultural Geography Reader*. Routledge, 41–51.

[21] Gillian R. Hayes. 2011. The Relationship of Action Research to Human-computer Interaction. *ACM Trans. Comput.-Hum. Interact.* 18, 3, Article 15 (Aug. 2011), 20 pages. https://doi.org/10.1145/1993060.1993065

[22] Ron D Hays, Cathy Donald Sherbourne, and Rebecca M Mazel. 1993. The rand 36-item health survey 1.0. *Health economics* 2, 3 (1993), 217–227.

[23] Julie S. Hui and Elizabeth M. Gerber. 2017. Developing Makerspaces As Sites of Entrepreneurship. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing (CSCW '17)*. ACM, New York, NY, USA, 2023–2038. https://doi.org/10.1145/2998181.2998264

[24] Amy Hurst and Shaun Kane. 2013. Making "making" accessible. In *Proceedings of the 12th International Conference on Interaction Design and Children - IDC '13*. ACM Press, New York, New York, 635. https://doi.org/10.1145/2485760.2485883

[25] Amy Hurst and Jasmine Tobias. 2011. Empowering individuals with do-it-yourself assistive technology. In *The proceedings of the 13th international ACM SIGACCESS conference on Computers and accessibility - ASSETS '11*. ACM Press, Dundee, Scotland, UK, 11. https://doi.org/10.1145/2049536.2049541

[26] Jolanda Jetten, Catherine Haslam, Cara Pugliese, James Tonks, and S. Alexander Haslam. 2010. Declining autobiographical memory and the loss of identity: effects on well-being. *Journal of clinical and experimental neuropsychology* 32 4 (2010), 408–16.

[27] Sandra Kerka. 1999. *Creativity in Adulthood [microform] / Sandra Kerka*. Number Accessed from https://nla.gov.au/nla.cat-vn5626159 in ERIC Digest ; No. 204. Distributed by ERIC Clearinghouse, [Washington D.C.]. http://www.eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=ED429186

[28] Mary E. Kite, Gary D. Stockdale, Bernard E. Whitley, and Blair T. Johnson. [n. d.]. Attitudes Toward Younger and Older Adults: An Updated Meta-Analytic Review. *Journal of Social Issues* 61, 2 ([n. d.]), 241–266. https://doi.org/10.1111/j.1540-4560.2005.00404.x arXiv:https://spssi.onlinelibrary.wiley.com/doi/pdf/10.1111/j.1540-4560.2005.00404.x

[29] Peter Laslett. 1991. *A fresh map of life: the emergence of the Third Age*. Harvard University Press, Cambridge, MA.

[30] Silvia Lindtner, Shaowen Bardzell, and Jeffrey Bardzell. 2016. Reconstituting the Utopian Vision of Making: HCI After Technosolutionism. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*. ACM, New York, NY, USA, 1390–1402. https://doi.org/10.1145/2858036.2858506

[31] Silvia Lindtner, Garnet D Hertz, and Paul Dourish. 2014. Emerging sites of HCI innovation: hackerspaces, hardware startups and incubators.

In *Emerging sites of HCI innovation*. ACM Press, New York, NY, USA, 439–448. https://doi.org/10.1145/2556288.2557132

[32] Makey Makey LLC. 2012. MakeyMakey: An Invention Kit for Everyone. Website. (2012). https://www.makeymakey.com/

[33] Josip Maric. 2018. The gender-based digital divide in maker culture: features, challenges and possible solutions. (2018). Prepublication.

[34] Mark Mather, L A Jacobsen, and K M Pollard. 2015. Aging in the United States. *Population Bulletin* 70, 2 (2015), 1–23. https://www.prb.org/aging-unitedstates-fact-sheet/

[35] National Institute on Aging. 2017. Residential Facilities, Assisted Living, and Nursing Homes. (2017). http://www.nia.nih.gov/health/residential-facilities-assisted-living-and-nursing-homes

[36] Jari Pirhonen, Hanna Ojala, Kirsi Lumme-Sandt, and Ilkka Pietil. 2016. 'Old but not that old': Finnish community-dwelling people aged 90+ negotiating their autonomy. *Ageing and Society* 36, 08 (9 2016), 1625–1644. https://doi.org/10.1017/S0144686X15000525

[37] Jie Qi, Leah Buechley, Andrew "bunnie" Huang, Patricia Ng, Sean Cross, and Joseph A. Paradiso. 2018. Chibitronics in the Wild: Engaging New Communities in Creating Technology with Paper Electronics. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, Article 252, 11 pages. https://doi.org/10.1145/3173574.3173826

[38] Susan Quine and Stephen Morrell. 2006. Fear of loss of independence and nursing home admission in older Australians. *Health & Social Care in the Community* 15 (2006), 212–220. https://doi.org/10.1111/j.1365-2524.2006.00675.x

[39] Gabriela T. Richard, Yasmin B. Kafai, Barrie Adleberg, and Orkan Telhan. 2015. StitchFest: Diversifying a College Hackathon to Broaden Participation and Perceptions in Computing. In *Proceedings of the 46th ACM Technical Symposium on Computer Science Education (SIGCSE '15)*. ACM, New York, NY, USA, 114–119. https://doi.org/10.1145/2676723.2677310

[40] Richard M Ryan and Edward L Deci. 2000. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist* 55, 1 (2000), 68–78. https://doi.org/10.1037/0003-066X.55.1.68

[41] Shari Sabeti. 2015. Creative ageing? Selfhood, temporality and the older adult learner. *International Journal of Lifelong Education* 34, 2 (3 2015), 211–229. https://doi.org/10.1080/02601370.2014.987710

[42] Robin M Sabo. 2017. Lifelong learning and library programming for third agers. *Library Review* 66, 1/2 (2 2017), 39–48. https://doi.org/10.1108/LR-08-2016-0065

[43] Jinsil Hwaryoung Seo, Benjamin Michael Copeland, Annie Sungkajun, Karla I. Chang Gonzalez, and Nicole Mathews. 2018. Re-powering Senior Citizens with Interactive Art Making: Case Study with Independent Older Adults. In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems (CHI EA '18)*. ACM, New York, NY, USA, Article LBW544, 6 pages. https://doi.org/10.1145/3170427.3188476

[44] Kimberly Sheridan, Erica Rosenfeld Halverson, Breanne Litts, Lisa Brahms, Lynette Jacobs-Priebe, and Trevor Owens. 2014. Learning in the Making: A Comparative Case Study of Three Makerspaces. *Harvard Educational Review* 84, 4 (12 2014), 505–531. https://doi.org/10.17763/haer.84.4.brr34733723j648u

[45] A Sleigh, H Stewart, and K Stokes. 2015. Open dataset of UK makerspaces: a user's guide. (2015). https://www.nesta.org.uk/report/open-dataset-of-uk-makerspaces-a-users-guide/

[46] Sowmya Somanath, Lora Oehlberg, Janette Hughes, Ehud Sharlin, and Mario Costa Sousa. 2017. 'Maker' Within Constraints: Exploratory Study of Young Learners Using Arduino at a High School in India. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. ACM, New York, NY, USA, 96–108. https://doi.org/10.1145/3025453.3025849

[47] Aase Stabell, Hilde Eide, Gunnel Anita Solheim, Kari Nasselqvist Solberg, and Tone Rustoen. 2004. Nursing home residents' dependence and independence. *Journal of Clinical Nursing* 13, 6 (9 2004), 677–686. https://doi.org/10.1111/j.1365-2702.2004.00942.x

[48] Nick Taylor, Ursula Hurley, and Philip Connolly. 2016. Making Community: The Wider Role of Makerspaces in Public Life. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*. ACM, New York, NY, USA, 1415–1425. https://doi.org/10.1145/2858036.2858073