TorBook: a tangible book for older adults

Iyubanit Rodríguez
iyubanit.rodriguezramirez@ucr.ac.cr
Universidad de Costa Rica
Alajuela, Costa Rica

Simón Rodríguez
snrodriguez@uc.cl
Pontificia Universidad Católica de Chile
Santiago, Chile

Andrés Lucero
lucero@acm.org
Aalto University
Espoo, Finland

Valeria Herskovic
vherskov@ing.puc.cl
Pontificia Universidad Católica de Chile
Santiago, Chile

ABSTRACT

Tangible User Interfaces allow users to manipulate digital information while taking advantage of their skills in using physical objects. This may be especially advantageous for older users with a lack of experience in technology use. This paper presents the implementation of *TorBook*, a tangible user interface in book format that detects the page that is open. We conducted an evaluation with 20 older adults to evaluate the functionality of *TorBook*. We find that participants feel comfortable with a tangible interface that uses a book metaphor, but that manipulation must be improved to become as similar as possible in its use as a regular book.

CCS CONCEPTS

• **Human-centered computing → Usability testing**.

KEYWORDS

Tangible, older adults, book, design

ACM Reference Format:
Iyubanit Rodríguez, Simón Rodríguez, Andrés Lucero, and Valeria Herskovic. 2019. TorBook: a tangible book for older adults. In *IX Latin American Conference on Human Computer Interaction (CLIHC '19), September 30-October 4, 2019, Panama City, Panama.* ACM, New York, NY, USA, 6 pages. https://doi.org/10.1145/3358961.3358966

1 INTRODUCTION

Globally, people are living longer, which means that between 2015 and 2050, the population of older adults will more than double [1]. Many older adults fully participate in the digital world, and most have a positive attitude towards technology [13], generally welcoming technology that improves their quality of life [2]. However, there are groups of older adults who, because of declining motor skills or lack of opportunity in accessing digital technology, are not able to fully engage in the use of technological devices.

CLIHC '19, September 30-October 4, 2019, Panama City, Panama

ACM ISBN 978-1-4503-7679-2/19/09…$15.00
https://doi.org/10.1145/3358961.3358966

Tangible User Interfaces (TUI) allow users to take advantage of their skills in using physical objects, making "digital information directly manipulatable with our hands and perceptible through our peripheral senses through its physical embodiment" [10]. Older adults who are not users of technology may be more willing to accept its use if it resembles technologies they are already used to [4]. The role of objects is important in the lives of older adults, and design of technology around important objects should consider underlying emotions surrounding the objects, the type of communication that will be implemented and how, how technology may enhance memories associated to objects, as well as which objects should not be intervened [19]. The book has been proposed as a tangible user interface (BUI, *book as user interface*) especially for older users, e.g. to send e-mails [6]. The book has also been used as part of a tangible interface kit to evaluate older adults' user experience [9]. This paper details the implementation of *TorBook*, a tangible book for older users, explaining how it was designed, tested and improved until it was able to be used by the older adults.

This paper is organized as follows. First, we present the related work on tangible books, and those tangible books especially designed for older adults. Then, we present the iterative design and implementation of *TorBook*, followed by our evaluation, discussion and conclusions.

2 RELATED WORK

2.1 Tangible books

Metaphors can help users understand interactive systems in an efficient way. Tangible books directly use a book metaphor, leveraging users' knowledge about how books work. The metaphor of the book is only partial, because other elements are included for the interaction with the user [16]. Tangible books have been proposed for several purposes. One such purpose is improving student learning, e.g. TaBooGa is a hybrid learning application to increase reading motivation in children, incorporating tangible elements to navigate through the book. That research concluded that a balance is required between the tangible elements so that students are motivated, but not distracted, from the target task [12]. Another example is an interactive book which uses paper circuits and projection mapping to teach veterinary students about bovine laminitis from interactive simulations. In this case, the participants expressed that the use of this platform made them more interested in anatomy than they previously thought [5].

Other books have been used for entertainment or/and memories, in which the user can place items such as images, videos and objects. Memory Book is like an album of photographs where the user can remember the experiences and emotions that they felt at that moment in their life [11]. Another book for entertainment and learning is a physical-digital hybrid: a physical book is synchronized together with a tablet so that when the page is flipped the content of the screen is modified. In this study, the participants had to imagine a story and finally, give it life in the physical book and on the tablet. In this study it was determined that the book is an expressive instrument with multiple levels of interaction [18].

2.2 Tangible book for older adults

Physical or cognitive disabilities related to age can have an impact when operating traditional user interfaces. However, ease of use and learning are key factors for the acceptance and adoption of new technologies, and that tangible design allows the development of easy-to-learn technologies for older without prior knowledge of computing [17]. Therefore, using tangible books can help older adults use technology. Some tangible books have been specifically created to help older users interact with technology or digital information. For example, one such book tangible interface with integrated instructions, providing a guided process to send and receive emails. This design was made to provide a familiar interface for older adults and avoid the unfamiliarity and possible problems of interaction with computers [6].

Tangible books have also been used to provide support in the activities carried out by older adults in their daily lives. Tertulibro is a hardcover device made of vinyl (mimicking the leather cover used in old books). The book integrates physical and digital media to help older adults share their discussions and narrations in a natural way, in informal but periodic social meetings. The prototype includes a control panel with buttons to activate the functions of the device, e.g. narrate, comment, pause and record. It was shown that tangible computing can be used to support the practices during these meetings [15]. Designing a tangible book aimed at older adults, which can identify the open page, will allow extending that design to different functionalities and interactions. Therefore, this paper aims to present the design and implementation of this type of interface.

3 DESIGN AND IMPLEMENTATION PROCESS: *TORBOOK*

The motivation to make *TorBook* was to design a book for older adults that identifies the page that is currently open, so that the book can provide other actions, services or tasks to older adults e.g. sound, manipulation of book elements, voice recording, among others. In the particular case of *TorBook*, each page would present a question that the user would have to answer and would be recorded through other mechanisms - i.e., it was necessary to know at any point in time which page was open. The development of *TorBook* was an iterative process that had three phases: design, materials and development.

3.1 Phase 1: Design

We used paper prototyping as a method to inspire ideas of how the book could be regarding shape, size, font, and other elements, and the best way to interact with the book. We made several design decisions based on the created prototypes. These were the following:

(1) The interaction should be as similar as possible to using a book in real life.
(2) The font size of the book should be suitable for older adults with vision limitations.
(3) The book should be intuitive for older adults, with low cognitive load.
(4) The book should be set on a slanted stand with an inclination of 120 degrees to allow the user to have a clear vision of the content.
(5) The book pages should be numbered, so users and researchers would be able to identify each page.

3.2 Phase 2: Materials

The main materials to make the book were the following: **Sheets of paper** is flexible material and allows the movement that the book needs. In addition, it is the material commonly used in books and therefore is well known by the users. It was decided that the stand would be made of **wood** because it is a strong and light material. In addition, this type of material can be attractive to users [14], and specifically in the case of older adults this aspect may be stronger by evoking reminiscing. Finally, for the implementation of the book, Arduino components and a battery will be used.

3.3 Phase 3: Development

The objective of the book is to be able to detect which page is open. For this to be possible, a signal from the book must be sent to the processor indicating which page is open. This section describes each of the prototypes we created while trying to fulfill the design requirements established in Phase 1.

3.3.1 Version 1. The binding used in this version is similar to rustic stitching. It uses a sheet which is divided in two: one page has the number of the question, while the other page has the question. To bind the pages of the book together, each page is pasted with the previous one as shown in Figure 1.

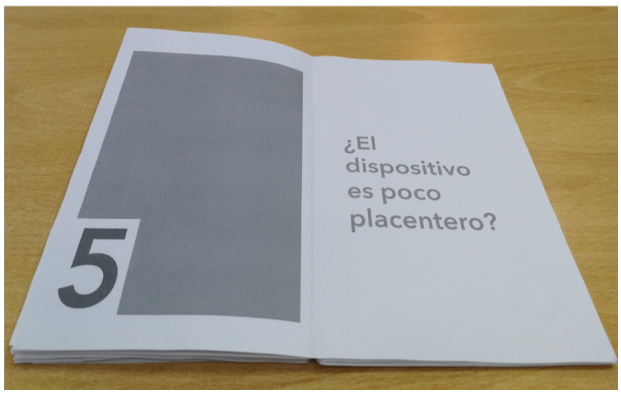

Figure 1: A page of the book with the question and question number.

Figure 2: Aluminum foil was added over the conductive paint.

The first version of the book was made using bond paper sheets, electrically conductive paint (Bare Conductive Electric Paint Pen 10ml) and electrical cables. To detect the current page, we placed conductive paint on the bottom edge of each page. The idea was that the conductive paint would generate contact with the front and back pages when the page was closed and a signal would be sent to the controller by means of the electrical cables, otherwise no signal would be sent if the page is open. The bottom of the page of the question number is connected to 5V, while the contact of the question page is connected to the controller to receive the signal. In this way, we can identify on which page we are.

During the tests in the laboratory, a problem with the contacts of the conductive paint was evidenced, since when the page is closed, contact with the previous and next pages is not achieved. This is because the pages of the book are very light, so they do not remain completely open. For this type of book to work, the user would have to continuously exert a force on the inferior edge of the page. Even then, if the user stops exerting the force, the pages separate again.

3.3.2 Version 2. The second version tried to solve the problem of the contact of the current page with the other pages (previous and next). Aluminum foil was added over the conductive paint, in order to increase the contact volume and its weight (see Figure 2). With this change, we expected that the contacts will be held together.

The results of laboratory tests showed significant improvements with respect to the previous version. However, the contacts stick on some occasions, so there is a rate of error in detecting that the book is open. This solution presents an aesthetic and functional improvement, so we decided to continue improving the idea of having the contacts covered with aluminum foil.

3.3.3 Version 3. Since the contact problem persisted, it was decided to change the conductive paint for 1mm thick magnets. The magnets were placed under the foil contacts. It was expected that the force exerted by the magnets on each page would be enough to keep the pages closed.

In the tests, there was an improvement in the detection of the open page, but the detection was still not completely reliable. In addition, it was evidenced that the paper was prone to be torn when used, affecting the operation of the book, because the contacts could break.

Figure 3: Cardboard lined book.

3.3.4 Version 4. To solve the problems of the resistance of the paper, we decided to use cardboard-lined paper (see Figure 3), which would be placed between the pages that are stuck. The idea was that this type of material would provide greater resistance on each page. As a result of this change, the book increased its thickness and weight, thus hindering the operation of the book (it became difficult to turn the page).

To improve the binding of the book, it was decided to use a ring-type binding. The ring used was extracted from a folder. The tests reflected a completely reliable page detection: every time a page is changed the correct signal is obtained in the controller. The ring used can be seen in Figure 4.

However, while testing, we felt that turning the pages of the book became unnatural and different from the expected feeling of turning a book page, requiring more force and a different pattern of movement for the page to pass through the rings.

3.3.5 Version 5. For version five of our project we decided to use a binding similar to staples, which consists of pages connected by the spine of the book. In this way, the cover of the book is connected to

Figure 4: Ring-type book.

the back cover of the book, while the center pages are connected, as shown in Figure 5.

Figure 5: Book used magnets of 1mm thickness.

This version still used 1mm magnets, and with the stapled binding, the pages were successfully detected. However, the thickness of the book increased significantly, since the book has 16 questions and 2 magnets are used for each page of the book. Even when the book improved its functioning, the aesthetics of it were not pleasant.

3.3.6 Version 6. The last version of our book used 0.4mm thick magnets, to improve the aesthetics of the book without losing functionality (see Figure 6).

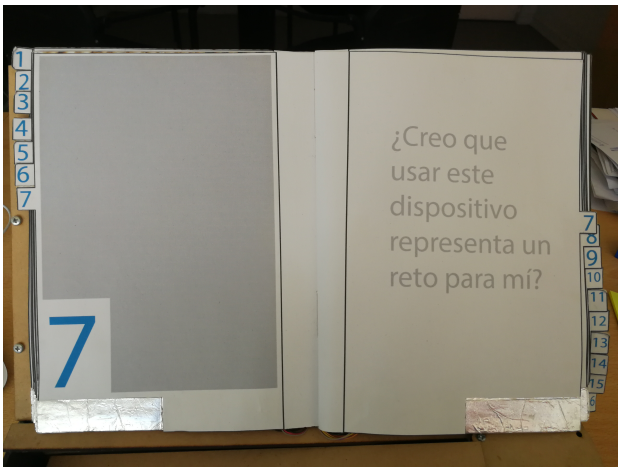

Figure 6: Final book

This version of the book fulfilled all the stated requirements. The final scheme of *TorBook* architecture is shown in Figure 7. The interface of the book was implemented using Arduino Mega 2560 R3 as a controller, SparkFun MP3 Player Shield for sound, a 12V battery and an on/off switch.

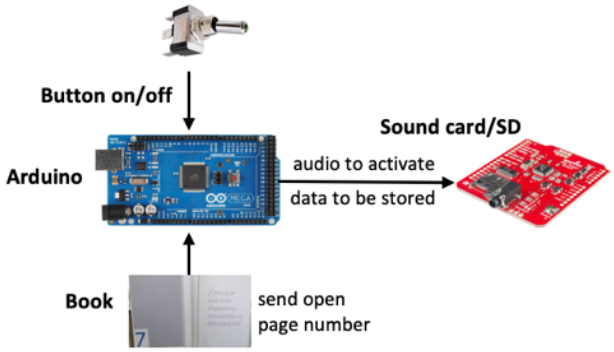

Figure 7: *TorBook* architecture scheme

3.4 How to use *TorBook*

In this research it was decided that the book had 16 questions and that the user read each question and answered it aloud.

The front page of the book is the cover, when opening the first page, the number of the page that is open is presented on the left side, while on the right side is the question that is asked of the user. The user after answering the question goes to the next page. If the user skips a page the system will indicate it to the user by voice.

4 METHODOLOGY

4.1 Recruitment, Participants and study procedure

To contact older adults we placed posters around the university campus to invite older adults to participate in our study, and we

used snowball sampling by asking participants if they knew another adult people who could participate in our research. The participants were compensated with a 15 USD gift card for their participation. The university ethics committee (170711013) approved this study.

A total of 20 older adults between the ages of 60 and 83 participated (6M, 14F, Avg. = 65.6, SD = 5.46). The inclusion criteria was the following: 1) being 60 years of age or older, 2) not having cognitive problems, and 3) speaking and understanding Spanish. The Table 1 a summary of the participants' data is shown.

Table 1: Study Sample

Age (average)			65.6
Gender	Female	14	70%
	Male	6	30%
Digital skills	None	8	40.0%
	Low	5	25.0%
	Basic	3	15.0%
	Above Basic	4	20.0%
Lives with	Family	17	85.0%
	Alone	3	15.0%
Educational level	None	1	5.0%
	Primary	8	40.0%
	Secondary	4	20.0 %
	Technical	4	20.0 %
	University	3	15.0 %

During the study, the participants used *TorBook* as part of the evaluation of a system for older adults to report their user experience with an application. This paper focuses on those aspects of the evaluation that are specific to the book interface. Each evaluation lasted 50 to 60 minutes. The following activities were carried out:

(1) First, a brief explanation about the purpose of the study was provided. Then, the participant signed an informed consent form (10 minutes).
(2) The participants then provided demographic data (5 minutes).
(3) The next step was to complete a digital skills questionnaire [7, 8] (10 minutes).
(4) The participants then interacted with a *TorBook*, as part of a study on a tangible interface that included the book. Each page of the book had a question for the older adult to answer out loud. During the evaluation a researcher observed and took notes (15-20 minutes).
(5) Finally, the first author conducted an interview to know the perception of the use of *TorBook* (10-15 minutes).

4.2 Data analysis

This evaluation focuses on those comments from participants that pertain only to the tangible book, as this study was part of a larger evaluation effort. We especially focus on participant's comments that are related to the technical difficulties in page detection. Quotes from the participants are presented here translated from Spanish.

5 RESULTS

All participants were able to successfully use *TorBook* and the book generally detected the open page correctly, without problems with the technological elements. Since out of the 20 participants, 10 had problems with the magnet and on average 3 times (pages). Also, they mentioned that this was the only problem they had when used *TorBook*.

Several participants found that the magnet of the book was not precise, i.e., it did not make immediate contact. One participant stated,

> "That part - managing the magnet - should be more precise, because the magnet does not stick well every time" (P16,F, none, 66 years).

Participants felt they had to press the magnet against the magnet of the previous page with greater force, to recognize the new page opened. This type of behavior was observed several times during the evaluation, with one user stating"I must use more force" (P7,M, above basic, 63 years). Another participant stated,

> "The handmade aspect is nice, but maybe (...) it could turn the page on its own, so it would not be needed to do that [help the paper by pushing it forcefully]" (P4,F, basic, 65 years).

A positive aspect is the size of the font "The questions are clear and the font size is large ... easy to understand" (P1,F, above basic, 70 years).

6 DISCUSSION

When designing tangible interfaces for older adults, their memories should be taken into account to create objects that are familiar to them to use, since this type of interaction will allow older adults to manipulate digital information with their hands and perceive it with the senses [10]. In the same way, in this study older adults used the tangible interface almost without assistance from other people (only in the case that the magnet failed to make contact), which is understandable if we take the fact that older adults know as use a physical book, and therefore, manipulation of physical objects is not unusual.

The interaction granted by a tangible interface for older adults should happen in a natural way, without inconsistencies with the real life objects used as metaphors [3]. Our results indicate that the manipulation of the book was not unknown to older adults. However, during the manipulation on some occasions the contact of the magnet with the previous page was not accurate, which made our participants wonder if they were using the book correctly, since they had to press the part of the magnet, making the interaction unnatural when compared to a physical book. This type of inconvenience makes older adults feel insecure and that the system is not consistent. Therefore, *TorBook* must evolve to become as similar as possible and transparent in its use as a regular book, hiding the technological aspects: the magnets should be invisible and the users should feel confident that whenever a page is open, the interface will correctly detect which page it is without additional manipulation.

7 CONCLUSION

This study presented the implementation of a tangible book for older adults, that detects the page that is open. This may be useful for many other projects that require detection of which page the user is looking at.

We found that older adults felt comfortable with the book, even as part of a technological interface, because the interaction with a book is natural for them. But there was a problem with the contact of the imams, which in some occasions caused the participants to become confused with the operation of the book. This problem is more about technology than about knowing how the book works.

In terms of future work, we will improve the book to make it as close to a regular book as possible, hiding those aspects that are related to page detection (e.g. the magnets). We will also work on evaluating the book in different contexts, as such an interface may be useful not only for older adults but also for other populations, e.g. children.

ACKNOWLEDGMENTS

This project was supported partially by CONICYT-PCHA/Doctorado Nacional/2014-63140077 and CONICYT/FONDECYT 1181162 (Chile).

REFERENCES

[1] [n.d.]. Ageing and health Fact Sheet. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health. Accessed: 2019-06-06.

[2] Neena L. Chappell and Zachary Zimmer. 1999. Receptivity to new technology among older adults. *Disability and Rehabilitation* 21, 5-6 (1999), 222–230. https://doi.org/10.1080/096382899297648 arXiv:https://doi.org/10.1080/096382899297648 PMID: 10381234.

[3] M. Cho, K. Jeong, and K. Jeong. 2013. Design Principles of User Interfaces for the Elderly in Health Smart Homes. In *International Symposium on Sustainable Healthy Buildings (SHB2013)*. 45–59.

[4] Graeme W. Coleman, Lorna Gibson, Vicki L. Hanson, Ania Bobrowicz, and Alison McKay. 2010. Engaging the Disengaged: How Do We Design Technology for Digitally Excluded Older Adults?. In *Proceedings of the 8th ACM Conference on Designing Interactive Systems (DIS '10)*. ACM, New York, NY, USA, 175–178. https://doi.org/10.1145/1858171.1858202

[5] Margaret Cook, Jinsil Hwaryoung Seo, Michelle Pine, and Annie Sungkajun. 2018. Paper Circuitry and Projection Mapping: An Interactive Textbook Approach to Veterinary Education. In *Proceedings of the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '18)*. ACM, New York, NY, USA, 131–135. https://doi.org/10.1145/3173225.3173290

[6] Scott Davidoff, Carson Bloomberg, Ian Anthony R. Li, Jennifer Mankoff, and Susan R. Fussell. 2005. The Book As User Interface: Lowering the Entry Cost to Email for Elders. In *CHI '05 Extended Abstracts on Human Factors in Computing Systems (CHI EA '05)*. ACM, New York, NY, USA, 1331–1334. https://doi.org/10.1145/1056808.1056909

[7] European Commission . 2010. *Measuring Digital Skills across the EU: EU wide indicators of Digital Competence*. Technical Report. Imported from http://ictlogy.net/bibliography /reports/projects.php?idp=2685.

[8] A. Ferrari. 2012. *Digital Competence in practice: An analysis of frameworks*. Technical Report. Research Centre of the European Commission, Seville, Spain.

[9] Rodríguez I., Karyda M., Lucero A., and Herskovic V. 2019. Aestimo: A Tangible Kit to Evaluate Older Adults' User Experience. In *International Conference on Human-Computer Interaction*.

[10] Hiroshi Ishii et al. 2008. The tangible user interface and its evolution. *Commun. ACM* 51, 6 (2008), 32.

[11] M. C. Juan, B. Rey, D. Perez, D. Tomas, and M. Alcañiz. 2005. The Memory Book. In *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in Computer Entertainment Technology (ACE '05)*. ACM, New York, NY, USA, 379–380. https://doi.org/10.1145/1178477.1178558

[12] Rebecca Linke, Tina Kothe, and Florian Alt. 2017. TaBooGa: A Hybrid Learning App to Support Children's Reading Motivation. In *Proceedings of the 2017 Conference on Interaction Design and Children (IDC '17)*. ACM, New York, NY, USA, 278–285. https://doi.org/10.1145/3078072.3079712

[13] Tracy L. Mitzner, Julie B. Boron, Cara Bailey Fausset, Anne E. Adams, Neil Charness, Sara J. Czaja, Katinka Dijkstra, Arthur D. Fisk, Wendy A. Rogers, and Joseph Sharit. 2010. Older adults talk technology: Technology usage and attitudes. *Computers in Human Behavior* 26, 6 (2010), 1710 – 1721. https://doi.org/10.1016/j.chb.2010.06.020 Online Interactivity: Role of Technology in Behavior Change.

[14] N. Patle. 2016. *LinkingPark: Design of a physical interface to enhance public engagement in an emerging smart city*. Technical Report. UCL Interaction Centre, University College London.

[15] Oscar Peña, Deysi Ortega, Edgar Barreras, Mara Balestrini, and Mónica Tentori. 2014. Integration of Physical and Digital Media to Allow Older Adults Collectively Share Narratives During Reading Groups. In *Proceedings of the 5th Mexican Conference on Human-Computer Interaction (MexIHC '14)*. ACM, New York, NY, USA, Article 53, 4 pages. https://doi.org/10.1145/2676690.2676699

[16] Jennifer Pearson, George Buchanan, and Harold Thimbleby. 2010. HCI Design Principles for Ereaders. In *Proceedings of the Third Workshop on Research Advances in Large Digital Book Repositories and Complementary Media (BooksOnline '10)*. ACM, New York, NY, USA, 15–24. https://doi.org/10.1145/1871854.1871860

[17] Wolfgang Spreicer. 2011. Tangible Interfaces As a Chance for Higher Technology Acceptance by the Elderly. In *Proceedings of the 12th International Conference on Computer Systems and Technologies (CompSysTech '11)*. ACM, New York, NY, USA, 311–316. https://doi.org/10.1145/2023607.2023660

[18] Cristina Sylla, Ana Carina Figueiredo, Ana Lúcia Pinto, Pedro Branco, and Nelson Zagalo. 2014. Merging Physical and Digital White Canvas to Unleash Children's Creativity. In *Proceedings of the 2014 Workshops on Advances in Computer Entertainment Conference (ACE '14 Workshops)*. ACM, New York, NY, USA, Article 13, 9 pages. https://doi.org/10.1145/2693787.2693807

[19] Kate Vaisutis, Margot Brereton, Toni Robertson, Frank Vetere, Jeannette Durick, Bjorn Nansen, and Laurie Buys. 2014. Invisible Connections: Investigating Older People's Emotions and Social Relations Around Objects. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '14)*. ACM, New York, NY, USA, 1937–1940. https://doi.org/10.1145/2556288.2557314