Improving user experience of assistive technology through codesign and 3D printing: a case study from cancer treatments

Alessia Romani[1,2][0000-0001-8602-0974], CarolinaMaria Consonni[1] and Marinella Levi[1][0000-0001-5921-7202]

[1] Department of Chemistry, Materials and Chemical Engineering "Giulio Natta", Politecnico di Milano, Piazza Leonardo da Vinci 32, 20133 Milano, Italy
[2] Design Department, Via Durando, 20158 Milano, Italy
alessia.romani@polimi.it

Abstract. Stigmatization negatively affects the quality of life of people living with cancers or chronic diseases. This issue often arises from the use of assistive technology and medical devices during daily activities. These products may create barriers within the social context rather than encourage inclusiveness. This work aims to investigate the role of codesign and digital technologies, i.e., 3D printing, in improving the user experience of assistive technology. The focus is to reduce or eliminate the stigma-related issues and improve the quality of life through codesigned customizable assistive products. A codesign process was carried out within the case study of "B.EAUTYlities", a project focused on the daily life needs of people with cancers or chronic diseases. The design experimentation resulted in the development of two customizable products to manage a central venous catheter for cancer treatments during the user's daily routine, i.e., protecting the catheter during outdoor activities or showers. Two online open-source configurators were developed to allow users to customize their device and manufacture it with low-cost 3D printing processes. Stigma-related issues can be mitigated thanks to the users' active role during the codesign process since their perception and feedback can be considered a key aspect to design new assistive products. Digital technologies and customization can spread accessible assistive technology, as well as open-source principles and distributed manufacturing networks. The user experience may be positively affected not only by the efficacy of these products in fulfilling their primary function but also by their customization, strengthening the emotional attachment to the products.

Keywords: Peripherally Inserted Central Catheter (PICC), Mass customization, 3D printing, Inclusive design, Open design, Digital fabrication.

1 Introduction

Assistive technology represents a powerful way to improve the quality of life of people dealing with impairments and chronic diseases. Its main goal is to enhance the well-being of an individual by increasing the autonomy level within the daily life context. The use of these products is aimed not only to increase a specific functional ability but also to enhance the users' social inclusion [1]. However, the innovation of these products is mainly driven by technology, ergonomics, and their technical feasibility, resulting in a limited users' engagement during the design process. Other key aspects related to the user experience and perception are generally neglected [2, 3]. For instance, the aesthetics of an assistive technology product plays a key role in showing or hiding an impairment and, consequently, in limiting its stigmatization in everyday life. Indeed, an assistive product is often recognizable, threatening the users' daily habits. Its aesthetics acts as a stigmatizing mark that creates social barriers. As a result, these kinds of products are often used for a limited period before their abandonment [4].

Design assumes a crucial role in avoiding the abandonment of assistive devices. Since assistive products can be linked to stereotypes, practitioners have to understand the causes behind the stigmatization in a specific social context, contrasting the abandonment of such assistive devices through stigma-free products [5]. Nevertheless, users' subjectivity and self-perception still represent challenging aspects for inclusiveness. Even if different projects involved the users to design new assistive devices [6–8], only a few works focused on stigma-free solutions [9]. The role of user participation in improving the user experience through the development of stigma-free products has not been adequately defined yet, as well as the contribution of digital tools [8, 10].

This paper explores the role of codesign and digital technologies, especially 3D printing, to foster the inclusiveness of assistive technology products in users' daily habits by improving the user experience. This work shows the results of “B.EAUTYlities”, a case study focused on codesign activities for people living with cancers or chronic diseases. First, an overview of the methodology is resumed together with the codesign process. A description of the results is then provided by briefly presenting IF and THEN, the two developed assistive products. Their goal is to help the user to handle a Peripherally Inserted Central Catheter (PICC) for the cancer therapies in everyday life situations. Afterward, the paper discusses the contribution of codesign to reduce the stigmatization and improve the user experience, as well as the role of customization and 3D printing. Thanks to user engagement, codesign may encourage the development of stigma-free solutions by considering aesthetics, user experience, and social acceptance as the main goals. However, the users should be effectively engaged through the design process. Digital technologies can facilitate the use of the products by making them more accessible regardless of the specific disease, widening the perspective. Customization is therefore a key aspect, raising the emotional attachment to the products.

2 Methodology

The activities of “B.EAUTYlities” were carried out in collaboration with “Fondazione Near Onlus”, an Italian association of young people with chronic and rare diseases, +LAB, 3D printing lab at Politecnico di Milano, and a medical staff group made by one nurse and two hematologists. This project engaged volunteers from 15 to 35 years old living with cancer or rare diseases in codesign activities for new assistive products.

The principles of codesign, or participatory design, were considered in designing the experimentation. In this work, the researcher took part in the codesign process in first-person as a designer together with the users and the different stakeholders, i.e. the medical staff and the caregivers, since this holistic framework encourages interdisciplinary cooperation and innovation development [11]. Fig. 1 depicts the workflow of the overall research. The codesign process was focused not only on the outcome, i.e., the assistive product, but also on the definition of the brief proposals. In detail, the left part of the graph is related to the validation of the briefs for the assistive products, understanding the users' needs, and defining the briefs. The first step corresponds to the detection of those needs, which can be collected during a starting workshop. Further discussion workshops help in understanding the needs, translating them into different briefs. Thanks to further investigations and some specific interviews, the final briefs can be defined and validated. Different stakeholders may be involved in these activities, i.e., the designers, the users, the caregivers, and the medical staff. The right part of the graph focuses on the development of the assistive products for the concept definition and product development phases. After the brief validation, some concepts can be generated and tested through design prototypes and first user trials. Further tests can be done after the concept validation to define the product configuration. Finally, product customization is defined through the development of the corresponding parametric configurators for the product configurators [8]. In this case, the design process is more focused on very specific briefs, hence the codesigners can be limited to the designers and the users, giving to the other stakeholders the role to validate the proposal.

Design prototypes were created by using a fused filament fabrication (FFF) low-cost 3D printer (Prusa i3 MK3S by Prusa Research, Czech Republic) with Polylactic acid (PLA) or Polyethylene terephthalate glycol (PETG) filaments. Flexible silicone was cast into 3D printed molds for water-proof applications. 3D printing gcode files were made with an open-source slicer (“Prusa Slicer” by Prusa Research), and online configurators for customization were designed by using Grasshopper for Rhinoceros (Robert McNeel and Associates, US), and the plugin from ShapeDiver GmbH [12].

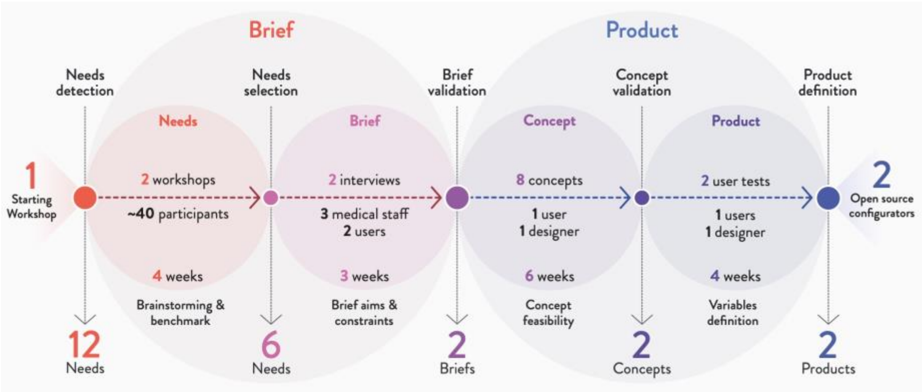

Fig. 1. Main workflow: needs detection from the workshop; needs selection; brief validation; concept validation; product definition; customization. The left part relates to the validation of the brief, whereas the right part deals with the development of the assistive products.

3 Results and Discussion

Different stakeholders were included throughout the codesign process as proper codesigners. They were seen as “experts of their own experiences”, providing some expertise that could not be obtained otherwise. Non-hierarchical collaboration between the user and the designer was encouraged in the second part of the workflow to codesign the products. Different activities were used to involve the stakeholders (Fig. 1 and 2).

Workshops were used to detect a set of needs to work on and deepen the debate, and the first screening was done in a non-hierarchical way, according to the participants’ feedback. In particular, the request was to think about some needs that the participants may encounter within their user journey. Most of them were related to specific daily habit actions during the cancer treatments (studying during the chemotherapy, managing the intravenous tubes, protecting a central venous catheter during a shower), or the usability of conventional assistive devices (hooking the crutches or transporting them on a bike). Some needs may be felt regardless of a specific disease (transporting a suitcase, opening jars). The desire for stigma-free solutions was shared amongst the participants, and some needs were focused on this aspect (pill organizers or avoiding the stigmatization of cancer treatments during leisure activities). Two additional workshops were then made to narrow down the discussion and discard some needs.

Some interviews were carried out to define and validate the briefs. The users gave some feedback on the perception of alternative existing solutions and their personal experiences related to the issues. Two needs were selected to define the briefs for the next phases: the protection and the stigma mitigation of central venous catheters, especially PICCs. One nurse and two hematologists were interviewed to validate those briefs and collect some critical aspects through two demos, i.e., the main parts of a PICC, its dressing, maintenance, use, and side effects from infections or wrong uses.

3D printed prototypes were useful to check the technical feasibility, aesthetics, user experience, and perception. The user and the designer organized short and frequent meetings focused on the definition of the principles and the stigma-related issues. The two concepts were further developed through two simulated user journey tests. This phase was also useful to define the configurator for the customization. The variables were chosen by prototyping some variants through the parametric definition.

Fig. 2. Activities during the codesign workflow of "B.EAUTYlities": (a) needs detection from the workshops, (b) simulation and discussion of the user journey during the interviews, and (c) user tests of the prototypes during the concept development.

Cancer treatments may require mid- and long-term curative therapies administered thanks to intravenous accesses such as Central Venous Catheters (CVCs). Peripherally Inserted Central Catheters (PICCs) represent one of the most used accesses for chemotherapy. PICCs are generally about 50 centimeters long and can be inserted with local anesthesia into the peripheral veins of the upper arm. Since a PICC ends outside the superior mid-arm through an incision, constant maintenance and dressings are required to avoid complications and failures [13, 14]. The users deal with different issues that may affect their habits. Some activities may be perceived as less comfortable or dangerous and can be restricted by the guidelines provided by the medical staff, i.e., having a shower or a bath. Living with a PICC also represents a challenge for its emotional and psychological impact since it is clearly visible on the arm. Hence, it can generate worry about physical contact and body acceptance, affecting user experience [14, 15].

The two briefs defined in "B.EAUTYlities" resulted in two different products: IF and THEN (Fig. 3). IF helps to handle a PICC during daily life activities (Fig. 3a). It protects the line and its dressing from accidental movements and prevents the removal from its site. Thanks to its holed pattern, humidity can be avoided to limit the infection risks. This product can be 3D printed in PLA with a low-cost small-scale 3D printer. The shape of the 3D printed part can be modified with a standard hair dryer, according to possible drawbacks, i.e., swellings of the arm. The product can be laced as an accessory product rather than an assistive device. THEN aims to protect the PICC during showers and baths (Fig. 3b). It covers the line and its dressing from accidental water during daily hygiene, and it can be adapted thanks to the engraved pattern and its silicone material. The PLA mold of THEN can be customized and 3D printed with a specific online configurator, and a non-toxic silicone can be poured into it. The product can be laced as an accessory. Both products can be customized through an online open-source configurator. The configurator of IF and some variants are visible in Fig. 4.

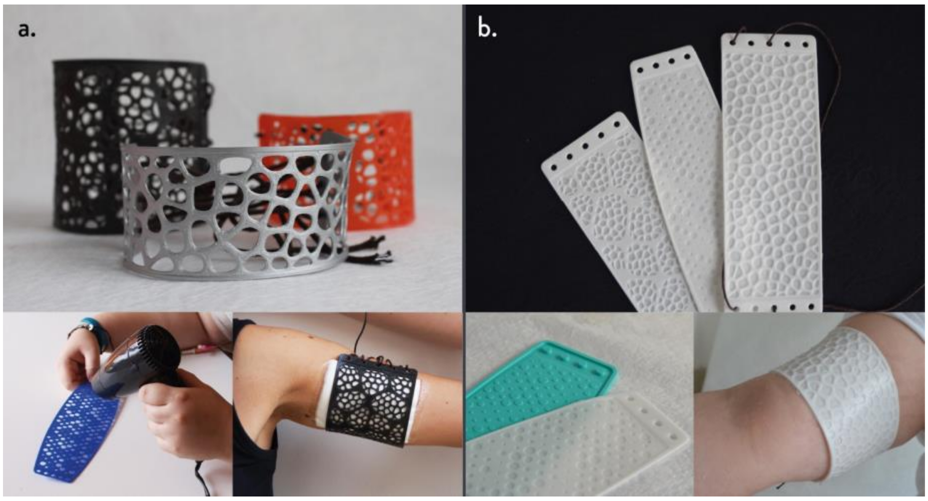

Fig. 3. Assistive products from "B.EAUTYlities": (a) IF (variants, adaptation through a hairdryer and final use); (b) THEN (variants, manufacturing through 3D printed molds and final use).

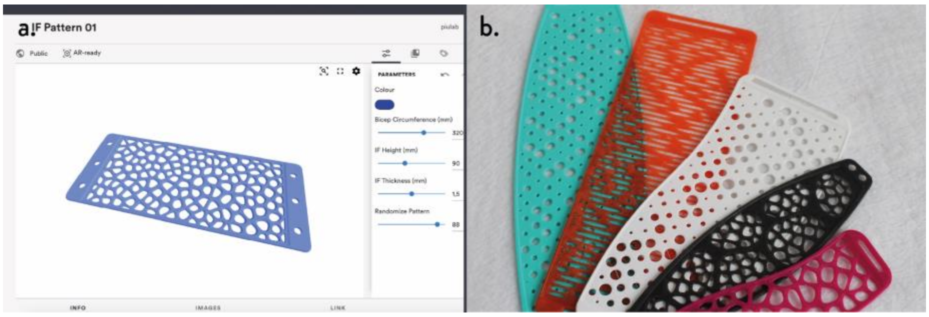

Fig. 4. User customization of IF and THEN: (a) open-source online configurator interface on Shapediver [12] (preview at: https://www.shapediver.com/app/m/if-pattern-01); (b) product variations of IF obtained with low-cost desktop-size 3D printers.

Involving the users in the design process of assistive technology brings several benefits such as designing new products that best fit the specific needs. Even though the acceptance of an assistive product is strongly subjective and depends on different factors, codesign activities can help in reducing the stigmatization thanks to the active role of the users. Considering the user as a codesigner helps in learning from his/her feedback and expertise. His/her contribution can be not only considered for the technical aspects or the usability of a specific product but also its user experience, aesthetics, and perception. Hence, stigma-related issues can be considered at the same level as the technical requirement. In general, users avoid using stigmatizing products, even though their primary functions can be easily accomplished, especially in social contexts. As mentioned before, a product can potentially show or hide a specific impairment [4]. However, some medical devices are difficult to hide. For instance, a

PICC cannot be hidden if the user is wearing a t-shirt, causing different behaviors, i.e., wearing a long-sleeved top to cover the PICC despite high temperatures. Designing an assistive product that hides the primary function by highlighting the secondary ones could be a possible way to reduce the stigmatization of those kinds of products by partially associating the user experience of different products. This principle was followed especially for IF. It may be initially recognized as an accessory rather than an assistive device, changing the perception of the product within social contexts. The primary function is hidden by highlighting its secondary functions and moving the focus to the accessory product. Customization could help in increasing the emotional attachment of these kinds of products [7], and this could lead to use IF and similar products for their secondary uses.

The inclusiveness of accessible technology can improve thanks to codesign and digital technology. Codesign processes encourage considering the user perspective during the development of a new assistive product, including the stigma-related issues. Within this project, digital technology contributed to developing customizable products thanks to parametric design. This workflow allowed to create configurators that the users can use to create their variants of IF and THEN. Open Source principles can help in spreading the project to a broader audience of users that can purchase their version on their own [8]. Finally, 3D printing represents the most suitable technology to customize and self-produce these products. Low-cost 3D printers enhance the mass customization of low-tech assistive technology through distributed manufacturing strategies of individuals and maker spaces [16]. This network could also help the users to purchase their products during disruptive events, i.e., the Covid-19 pandemic.

4 Conclusions

This work studied the contribution of codesign and digital technologies to reduce the stigmatization of assistive technology products by improving the user experience. The methodological approach of the practice-based case study "B.EAUTYlities" was described together with its main outcomes, IF and THEN. The workflow of this project allowed to focus on the specific needs, briefs, concepts, and products by involving the users through workshops, interviews, and tests. Thanks to their active contribution, stigma-related issues were considered within the codesign process together with the other requirements. Moreover, the constant and frequent feedback between the user and the designer helped in defining and validating the final products. Their main aim is to support people living with a PICC for cancer treatments during everyday activities. The issues related to social acceptance and stigmatization can be mitigated not only through codesign processes and design strategies, i.e., highlighting the secondary functions, but also thanks to mass customization. Within this framework, open-source principles and digital technologies play a key role in facilitating the spread of accessible and inclusive customized solutions, and low-cost desktop-size 3D printing can pave the way to the distributed manufacturing of assistive products. Customization allows to enlarge the audience of users, i.e., with similar needs and/or impairments, and codesign activities can be carried out by taking this perspective-shifting into account, raising the inclusiveness of the solutions. Although these topics should be further investigated because of users' subjectivity, this work can be considered a pilot study to improve user experience of assistive products through codesign. Future works should: include a broader audience of users, different needs, and social contexts; consider different impairments and/or diseases; refine the methodological workflow by iterating the codesign process.

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