Design for Inclusion, Gamification and Learning Experience

edited by
Francesca Tosi, Antonella Serra, Alessia Brischetto, Ester Iacono

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 ISBN 9788891797780

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Impaginazione: Elena Di Rado e Camilla Benassai

Immagine di copertina: Camilla Benassai

Isbn 9788891797780

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7. Design and Prototyping for Disability. DÌA Case Study

by Francesca Ambrogio, Joelle Cifelli, Allegra Corrente Fornoni, Francesca Pian, Matteo Rossi, Francesca Toso, Maximiliano Romero

Abstract

The present paper introduces the approach applied for the creation of Dìa, an open source blood glucose meter controlled through an Arduino board. The project was developed during the "Intelligent Products" Design Studio of the Product Design Master Course at Iuav University of Venice.

At the beginning of the design process a User Research has been conducted. It consisted by diabetes-affected people interviews and online questionnaires. This phase was fundamental to achieve our objective: a user-oriented product. Starting from the existing Open Source project, the "Open Source Arduino Blood Glucose Meter Shield" that we found on hackaday.io, we have implemented it by integrating a code for the data transmission with a Node MCU, the design of the shell, the study of a new mechanism for the lancing and the creation of a Web App accessible both from the user and from the doctor.

"Dìa" is a product that has four main features: lancing, glucometer, sending data to a WebApp for smartphone and the creation of measurements history performed by the user. Dìa is an integrated product that allows the diabetic patient to have always the opportunity to sting the finger and detect the blood sugar: everything is inside one product connected to a WiFi and a WebApp. The study of the product and service is one of the foundations of our project because we are convinced that, despite the new sensor developed for diabetic person, the blood glucose measurement is the only measurement that the patient can really trust. An imperative is therefore to be able to maintain an historical measurement and, at the same time, have a dialogue at any time with the doctor, who has the possibility to check the glycemic trend of the patient. At the end of our study we've created a functional prototype, exhibited during the "Design Open Lab" at the Iuav University of Venice.

Keywords: *Design Open Source, User Centered Design, Learning Experience, Diabetic, Integrated device.*

7.1 Introduction

Dìa is a project of assistive technology developed according to the design method proposed by "Intelligent Products" Design Studio, of the Product Design Master Course at the Iuav University of Venice (Romero, Ferrari, Toso, 2018). After a desk research conducted on the devices that diabetic patients use daily to monitor their glucose level, we have focused our attention on the guidelines provided by the Italian healthcare system and on the devices disposable on the market. In this way we have analyzed the technology state of the art and the modality of use of the common devices. We have consequently decided to improve the design in compliance to an open-source project (Open Source Arduino Blood Glucose Meter Shield", hackaday.io). Our project is focused on the method, and so the gestures and habits of the patient that use the glucometer. The material chosen to make the product is the PLA.

User and Platform Identification. The project has been designed from an OpenSource perspective. We assumed as target users between 16 and 50 years old. We've set this target because the product requires basic knowledge of 3D printing and the dynamics of OpenSource projects in order to have access to the platforms and the technologies for its production.

For the distribution of "Día", the POSTA project (www.postaproject.org) has been chosen as reference platform from which it will be possible to see and download the project, build it, use it and implement it.

Identification of Existing Problems. Through these tools (questionnaires, users research and interviews) we have identified the glucometers' problems that can be classified in three categories:

- Usability;
- Functionality;
- Connection.

In particular, the critical issues regarding the "usability" are:

- glucose meters without the possibility of having a history of the measurements: The glucose meters currently available in the market, do not allow to "record" the daily measurements made by the user and consequently to create a history of the measurements themselves;
- glucose meters not very "usable" and ergonomic: currently glucose meters are uncomfortable; they involve a complex gesture of the users;
- absence of integrated glucose meters with lancing device: at the moment there are no devices that combine the two functions.

The "functionality" of the glucose meters is often reduced, missing, superficial, but despite these problems they are used as fundamental tools because they are essential for a diabetic patients. They use various technologies for measuring blood sugar such as extracutaneous or subcutaneous sensors.

As far as the chapter on connectivity is concerned, the discussion is divided into different subcategories because we are not only talking about a connection between the glucose meter and an application for smartphones, but also about telemedicine. More specifically:

- impossible to check the glycemic value due to an application on a smartphone (when the subject is not at home and makes a glycemic measurement with the current instruments);
- daily/weekly/monthly glycemic trend graph. So the absence of the possibility of an history;
- impossibility of telemedicine and the constant relationship with the treating doctor.

7.2 Metodology

The methodology proposed by the course required a direct and close relationship between designer and final user, in order to create a sort of collaboration to achieve a common goal. The steps followed for the realization of the project are:

- identification of the user;
- questionnaires;
- interviews;
- research on the state of art;
- project brief;
- concept definition;
- project development;
- final prototyping.

7.2.1 Identification of the User

The project has been designed from an OpenSource approach; it is assumed that the user is a diabetic patient aged between 16 and 50 years old. We have defined this target group on the basis of the questionnaires that we have diffused on internet, specifically we have used the Facebook platform. The result of the questionnaires revealed a strong presence of women with type 1 of diabetes in an age group ranging from 21 to 37 years old. The step after the questionnaires were individual interviews. As we defined the target audience, we identified two users who were in line with the results obtained.

7.2.2 Questionnaires

To investigate and have a better idea of the User Experience, we have drafted a questionnaire to submit through social networks; that choice has been made to enlarge our sample. The questionnaire was created with “Google Modules” and was published on Facebook in restricted groups of diabetic patients and on our personal pages.

The choice to publish the questionnaire on Facebook was motivated by the fact that we wanted our target audience to be relatively young people and open to new types of care/glycemic measurements.

The number of filled questionnaires was 95: 91 people have type 1 diabetes mellitus. We also noted that the average age of the people who answered was about 26 years with a majority of women.

An important fact obtained from the processing of the questionnaire data was that 89 diabetic patients use sensors to control blood sugar but they all said that they never go out without their traditional glucose meter. Based on the data collected, we decided to implement a new glucose meter: it’s an essential device for diabetic patients even though the most common products on the market are sensors. Companies tend to focus their attention on new sensors that use innovative methods for measuring blood sugar, but the glucosemeter is the only instrument that allowed to measure the real glicemic level.

7.2.3 Interviews

The people chose as sample for the investigation are Camilla 25 years old and Costanza 24 years old, both affected from type 1 diabetes.

The interviews allowed us to undertake a qualitative and personal analysis of the issues because they were conducted at two different times during the project. The first interview, that take place on December 4, 2018 with Camilla, was placed in the first period when were not considered yet the traditional glucose meters but only extracutaneous sensors for the detection of blood sugar. An important problem for Camilla is not having a regular life as regards meal times because doesn’t feel comfortable in using her glucometer. She has repeatedly claimed that although she is currently using the Dexcom G4 sensor, she never leaves the house without glucometer.

The second interview was conducted with Costanza. In that case it was possible to highlight issues and go deep considering the phase of the project, more mature. This second interview was conducted on January 9, 2019, when the clear objective to achieve was to create a glucosemeter.

The design change was determined by the comprehension of the impossibility of action, for our working group, in the field of sensors for glycemic control because it involves the use of technologies with very small size (almost exclusively owned by pharmaceutical manufacturers). Due to this costraint and many doubts arising from the words of Camilla, we decided to discover what was actually the importance of traditional glucose meters for the diabetics. We interviewed another person who uses the FreeStyle Libre sensor for blood glucose control and the pump for insulin intake, a very different situation from Camilla.

It was possible to identify the differences and similarities between the two people and to define our brief.

The problems encountered by Costanza are located in the user interfaces and in the shapes of the devices she currently uses; she also highlighted the importance of the glucose meter despite its inconvenience from different points of view. The questionnaire was our method of research and quantitative analysis. A questionnaire was drawn up, based on the research conducted, offering the user a range of possible answers with also the space for comments in case the ones proposed by us did not meet the needs.

7.2.4 Research on the State of Art

The state of the art that we have carried out is based on desk research of what is currently on the market regarding lancing devices and glucometers, in addition the study of existing Open Source projects. We also bought some lancing devices to be able to disassemble them and understand more in detail their internal structure to redesign it.

7.2.5 Project Brief

After the research phase, we have defined our project brief, consisting in a glucose meter with compact lancing device and dialogue integration with smartphone application for data communication.

Dìa was born from the need to have an integrated product so that the diabetic patient can limit the load of instrumentation to carry always with him. So, it's a product capable of lancing and measuring blood sugar. Dìa offers a very simplified exchange of data and information between the diabetic patient and the treating physician.The doctor can, at any time and from any device, have access to patient's page to see the content.

7.2.6 Concept Definition

The starting point is the OpenSource project "Open Source Arduino Blood Glucose Meter Shield" by M. Bindhammer.

The main points of this project have been:
- the Arduino firmware;
- the hardware component that governs it and therefore allows the reading of the level of glucose in the blood. Shield (printed circuit board) that, thanks to the use of connectors and TPS, allows the reading of blood.

Our intervention is divided into several aspects:
- elimination of the use of the LCD screen;
- new writing of Arduino's firmware by reformulating the logic of writing and operation;
- further implementation of the code given by the use of mathematical functions to reset all the operation of the printed circuit board for a device with capacity to work at 3.3 volts and not at 5 volts as in the firmware of the reference project;
- creation of an integrated and easily replicable product: lancing, blood glucose detection, blood glucose level LED feedback, product;
- study of a new lancing mechanism;
- product study;
- design and creation of a WebApp, which can be consulted from the patient's mobile device and from fixed workstations. Also from the doctor's PC, whichis in constant dialogue with the device and with the history of the measurements performed.

7.2.7 Project Development

The project development consists in the elaboration of the feedback given by the user on the problems found and the definition of formal and functional details, such as materials, electronics components, dimensions, position of the elements that allow user-product interaction.

7.2.8 Final Prototyping

The last step consists in the final prototyping of the project. The goal is to obtain a working prototype as similar as possible to the product previously designed and developed, both in term of form and functionality. The result was an integrated product that had inside the main and essential functions for the use of the glucometer. We've completely studied the lancing device part and its functioning in a way that is totally reproducible and reconstructible in 3D. The device can be reproduced by those who have basic knowledge of 3D printing and technological skills.

Fig. 7.1 - Render of final product and the design of the logo

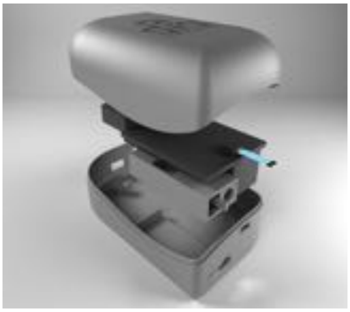

Fig. 7.2 - Render components and how they were places inside

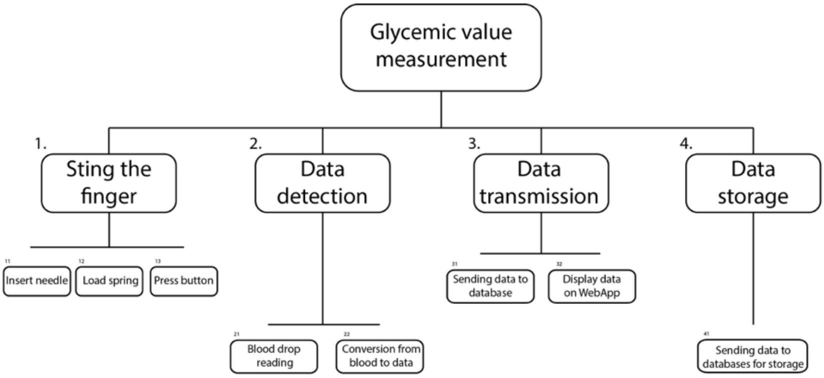

Fig. 7.3 - Task Analysis of the interaction between product and WebApp

7.3 Results

The described design methodology was fundamental for the prototyping of Dìa, an integrated product that allows the diabetic patient to always have the opportunity to sting the finger and detect the blood sugar: everything is inside one product connected to a WiFi and a WebApp.

7.3.1 The Product

The physical realization of the product required the improvement of the following skills:

1. ergonomic study of the size and position of the elements of interaction with the user (buttons, invitations to use), (Tosi, Rinaldi, 2015);
2. ability to develop the design of the object with various study models, keeping in mind the dimensions of the electronic components;
3. 3d modeling and preparation for 3d printing;

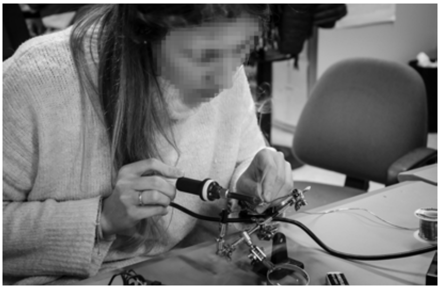

Fig. 7.4 - In this photo the moment of the soldering of the electronic components

Fig. 7.5 - The coding work that has been done for the Arduino and Shield code

Fig. 7.6 - External shell of the product in 3D

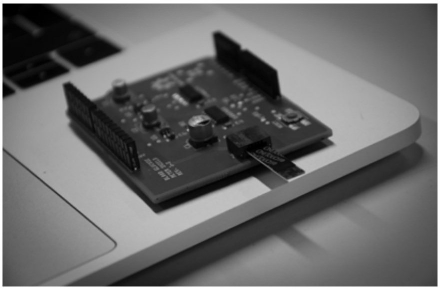

Fig. 7.7 - Internal product shield

4. fundamentals of electronics: learn and manage the main electronic components (creation of electrical diagrams and electronic welding);
5. programming basics: chip firmware writing based on the functionality required for the prototype (Arduino and Open Source libraries);
6. assembly of components.

The result was the realization of a 3d model of the components, printed in PLA with 3d printer, that made Dìa structure: body (which contains all the electronic components) and lancing. Consequently these parts have been assembled together with the electronic parts: on/off switch, 4 led, printed shield, chip (NodeMCU), 9v battery.

7.3.2 The Web-App

MySQL Database. Free software, defined as an open-source Relational database management system (RDBMS) available for free that uses Structured Query Language (SQL, the most popular language for adding, accessing and managing content in a database), consisting of a command line client and a server. It's known for its fast processing, proven reliability, ease of use and flexibility. MySQL is an essential part of almost all open-source PHP applications.

The database is structured according to a subdivision into tables:

1. Table users, in which are inserted Username, Password, Date of birth, Weight and sex, relating to each user previously registered on the online platform;
2. Values table, in which are inserted Username, date, time, glycemic value and comments/notes.

When the user takes the blood glucose measurement through the device, the device is sent to the database, registering in the Values section.

The Arduino only communicates the blood glucose value to the database; the date and time are managed by the MySQL server, which picks them up based on when the value is received.

Software used:

- HyperText Markup Language – HTML – is a markup language, created for the formatting and layout of hyperlinked documents available in web 1.0;
- JavaScript is an object and event-oriented scripting language, commonly used in client-side Web programming for creating dynamic and interactive effects on websites and web applications;

- CSS (Cascading Style Sheets) is a language used to define the formatting of HTML, XHTML and XML documents such as websites and related web pages;
- Adobe XD makes it easier to switch between graphic and programming code settings. Final export to Java and HTML.

7.3.3 Mode of Use

The user turns on the button on the device. When the device is on, the white LED blinking and it does not stop until it finds a Wi-Fi connection. When the Wi-Fi connection has been found, the user inserts the One Touch Ultra strip inside the product, stings his finger and places the drop of blood on the strip, where it is absorbed. The device analyzes the drop and provides a numerical data as outcome of the process, then the data is transmitted to the Node MCU which converts it and sends it to the online database. During the time that the data is stored in the database and arrives at the display on the app, the devide responds with a bright red-yellow-green feedback based on the glycemic value. Red (50-79, 231-280), Green (80-180), Yellow (181, 230). After that, the user can insert his/her credentials on the app and have a real time display of the glycemic data. From the app it's possible to see the trend of measurements made during the day or month. Next to each measurement the user can make notes and comments that are also functional for the doctor, who can have information on the profile.

7.4 Conclusions

The dialogue and integration of Open Source projects with other commercial products was one of the great challenges behind the Dìa project. The language of firmware had to be integrated with the language of "closed" products existing on the market. This is one of the problems that Dìa solves by widening its gaze and giving not only a functional opportunity, but also a coherent and expendable formal solution. Indeed the products on the market are protected by copyright and their firmware is not design to be customized, so working in a open-source perspective allowed the customization of the devices to and for end users.

Secondly, the use of the Webapp compared to a traditional application allows the user and the treating physician to have access at any time from any device in the world (PC, smartphone, tablet, etc.).

The enrichment and contribution provided by Dìa is: an ex-novo study of the shape of the product, components and lancing mechanism. From the construction point of view it is easy to assemble and build even for those who are not practical in the field. The increase of the software is surely important because the Arduino programming code, from which the project started, has been modified in order to develop a code that is able to dialogue directly with the WebApp and therefore does not force the user to use the PC whenever he needs to measure blood sugar. The analysis of the processing and storage of sensitive data was not taken into account at this stage of the project and can be considered as one of the possibilities for its implementation.

Acknowledgments

Dìa is a product designed by Francesca Ambrogio, Joelle Cifelli, Allegra Corrente Fornoni, Francesca Pian, Matteo Rossi. Thanks to the collaboration of the users, Camilla and Costanza and to Giovanni Borga for the technical support.

References

Bindhammer M., *Open source Arduino blood glucose meter shield*. Text available at https://hackaday.io/project/11719-open-source-arduino-blood-glucose-meter-shield. Accessed March 08, 2019.

Hodgins S., *NIRGM-Non-Invasive NIR Glucose Meter. Uses different wavelengths of light to shine through the skin in order to determine the amount of glucose present in the user's blood*. Text available at https://hackaday.io/project/5508-nirgm-non-invasive-nir-glucose-meter#j-discussions-title. Accessed February 28, 2019.

Maiocchi M. (2008), *Design e Comunicazione per la Sanità*, Maggiori Editore, Santarcangelo di Romagna (RN).

Maiocchi M. (2010), *Design e Medicina*, Maggioli Editore, Milano.

Novità terapeutiche da Bayer. Text available at www.diabete.net/novita-terapeutiche-da-bayer/tuttodiabete/anno-28-n%C2%B03-settembre-dicembre-2011/32094. Accessed January 01, 2019.

Ogrodnik P.J. (2012), *Medical Device Design*, Academic Press, Cambridge, Massachusetts (USA).

Pastore M.N., Kalia Y.N., Horstmann M., Roberts M.S. (2015), "Transdermal patches: history, development and pharmacology", *British journal of pharmacology*, 172, 9: 2179-2209. Text available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4403087/. Accessed December 11, 2018.

Romero M., Ferrari C., Toso F. (2018), *Designing and prototyping intelligent products for users with disabilities, a teaching experience* in *ICERI2018 Proceedings*, 11th annual International Conference of Education, Research and Innovation, Seville, Spain (pp. 5570-5577).

Tosi F., Rinaldi A. (2015), *Il Design per l'Home Care. L'approccio Human-Centred Design nel progetto dei dispositivi medici*, DIDAPRESS, Firenze.

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