DESIGN, ERGONOMICS AND 3D PRINTING: A PRACTICAL EXERCISE IN PROJECT FOR SOCKETS PLUGS COVERS

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Sockets plugs covers, Product design, 3D printing

1. Context

With the advent of electricity, household appliances became part of people's lives and, consequently, electrical outlets as well. With the presence of domestic sockets, electrical accidents started to happen. According to ABRACOPEL (Brazilian Association for Awareness of the Dangers of Electricity), in 2018, events with electric shock lead the ranking of accidents of electrical origin in the country, with 836 records of fatal and non-fatal cases.

The protectors for residential sockets arose from the need to prevent accidental contact with the electric current, especially by children. Even with the evolution of home appliances and safety issues for residential sockets, it is noted that accidents related to accidental contact with the power grid still occur.

This way, the objective of the present study was to investigate relevant aspects to develop new socket protectors that are more efficient, comfortable and safe for users, considering ergonomic and usability criteria, through the integration of the disciplines of Product Design and Ergonomics, on undergraduate design course at the Universidade Federal do Maranhão (UFMA).

The study results in a conceptual proposal for new plug protectors, which had been tested and evaluated by users based on the developed prototype. The ergonomic and usability criteria in this product project guided the choice of alternatives, in order to improve the functional aspects and consequently the satisfaction of individuals.

2. Method

For the present study, the design methodology of Bernd Löbach (2000) was used, which divides his method into four phases: preparation phase; generation phase; evaluation phase and implementation phase. These steps guided the entire development process of this project.

For the preparation phase, the techniques used for the development of the product project were applied (LOBACH, 2000) such as Needs Analysis, Comparative Product Analysis, Target Audience Analysis, Market Analysis, in addition to ergonomics techniques such as Systematization Man-Machine-Task e Task Flowchart for the performance of ergonomic appreciation (MORAES AND MONT'ALVÃO, 2000). For verification tests, the Usability Tests and Erick's Test (CAVALCANTI, 2002) were used. Finally, for Satisfaction Analysis, the SUS - System Usability Scale questionnaire (BROOKE, 1986) was applied.

In the generation phase, Moodboard (MCDONAGH AND DENTON, 2005), Mind Map (BUZAN, 2005), Brainstorming (VIANNA et al., 2012) and Brainwriting (MICHINOV, 2012) were used in order to stimulate creativity in generating ideas.

For the third stage, the evaluation phase, the most plausible solution is defined in view of the established criteria and, for this, a concept product was generated and a mockup was developed in order to check the preliminary dimensions of the product, taking into account the principles anthropometry (PASCHOARELLI, 2000) and biomechanics (IIDA 2005).

In the realization phase, the technical design and digital modeling of the product had been elaborated, and finally prototyping was carried out using 3D printing technology.

Finally, in the last stage of validation, the Usability Tests, the Erick Test and the SUS questionnaire were reapplied, with the prototype developed.

3. Results

Through questionnaires and semi-structured interviews, which took place with 40 interviewees between 18 and 56 years old, it is possible to trace the existence of more than a direct audience, they are parents and children aged 1 to 4 years; and as an indirect audience, other family members and nannies. In addition, it is identified that the demand and use of the products is mostly made by the female audience (71%) and that those who make the most use of the product (87%) live with small children, using during the first 4 years of age. Those who reported disuse (41%) say that one of the main reasons would be the absence of young children at home.

From initial usability tests with one of the most popular plug protector models in the Brazilian market, it was possible to verify and validate the actual flow that users perform to use the plug protector, from a simulation using a cell phone charger and a protector. In parallel, the Erick Test was applied, where by printing on an ink stain by direct contact, after using the accessory, it was possible to verify that the handle areas used by users to remove the product had very small dimensions.

Through the application of the SUS - System Usability Scale questionnaire, carried out with five mothers who participated in the previous tests, it was possible to reaffirm the problematization. The average of the results obtained in the questionnaires was 67.5, which implies that the product has usability problems.

After the stage of generating ideas, it was possible to arrive at a concept model for the new product, which in the subsequent evaluation phase had its preliminary dimensions analyzed and defined, mainly in the catch areas. A mockup developed with epoxy mass was used, taking into account the data collected from the table by Pheasant (1996) presented by Paschoarelli (2000), such as the width of the thumb, width of the index finger and maximum functional opening of men and women, considering the 5th and 95th percentiles of both and the standard for plug plugs, NBR 14136/02.

From the realization phase, the technical drawing of the product was obtained with the measures established in accordance with all the criteria already mentioned, which led to digital modeling and 3D printing of the developed prototype.

The new model follows the premise that the user can use the socket without the need to remove the protector. Among its main characteristics are a larger and rough side grip area, ensuring more firmness to handle the product; a semi-automatic locking mechanism, consisting of plates and springs, where the socket holes would be blocked. For use, the user would place the pins in the hole of the accessory itself and with a sliding movement downwards would result in the pins accessing the socket. In addition, a self-adhesive surface is desirable for better attachment to the socket, to further prevent accidental removal by children.

Finally, usability tests were applied again, maintaining the same tasks performed in the initial test, the Erick test and the SUS questionnaire. With the usability tests, it was noticed that the time spent to simulate the use was relatively fast, from 10 to 15 seconds. The grip area of the product was easily recognized by the users and most of them used only one hand, in a tweezers movement, to remove the product. There was an increase in the contact area for removing the prototype, through the Erick test, and a positive growth in the

level of user satisfaction, through the SUS, where results were obtained above the acceptable average, not pointing to problems usability as in the evaluated popular model.

4. Conclusion

Socket protectors are extremely important accessories to reduce the risk of electrical accidents in the home. However, it was found in the research that they are little used because they do not meet the user's needs efficiently.

The project sought to guarantee the user greater comfort and safety, due to a semi-automatic system to isolate the orifices from the socket, reducing the phases of the task. In addition, it has a larger contact area to ensure easier removal of the accessory, by adults, when necessary. The access and consultation to the anthropometric and biomechanical tables and the NBR 14136 standard were of great value in thinking about the dimensioning and handling aspects of the product.

The strategy to hinder the removal of the accessory by children was to design the handle area on the side edges of the product, knowing that the functional opening of the child is smaller than the measures of the total length of the proposed plug protector. A sticky surface was proposed for better fixation, aiming to minimize the risk of accidental removal. The tests performed show that there was an improvement in the problems identified and an increase in user satisfaction due to a better user experience. In general, the project presents a satisfactory alternative for the development of new models of outlet protectors.
In addition, the important integration between the disciplines of Product Design and Ergonomics is highlighted here, which, together with 3D printing technology, allowed students the experience of developing a project for a real problem, from the analysis of the problem to the validation of the developed alternative.

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