Physical Product & User Interaction Design of a Detachable Battery module for Bike to E-Bike Conversion

By Fotios Rappos
Industrial Design Engineering, Bachelors, University of Twente, Netherlands.

The Bachelor Assignment was provided through an external organization called Swugo. Swugo is an electric mobility company that develops affordable solutions for e-bikes to their customers. Their goal is to make electric bicycles accessible to more people with their product service system. The product in development is an electric bike conversion kit. The intent of this kit is to be installed in any conventional bicycle and turn it into electric. Then through a monthly subscription, the user has access to that kit as well as servicing (Swugo, 2022).

The aim of the project was to develop a new physical design and also user interaction features for the relevant parts of the kit, in order to offer a compelling user experience that is going to add value to the user's life. The physical design was the battery assembly and the way that the battery is mounted on the bicycle frame. While the design for User Interaction, indicated the way that the user would interact with the physical components of the product and the features that would add value to their life. The battery's design contained a preliminary assembly that indicated the dimensions and formfactor of the housing of the electronic components such as the battery system, but also where those components are placed within that housing. Also a battery base, that is mounted on the bicycle, was designed for the battery to be installed on.

The design process involved research phases from which the product would be further defined. First was the Literature Research Phase, which provided insight into the world of micro-mobility, key technologies & features, competitors, and battery technologies that would be beneficial currently and in the future. The second phase was the Ideation Phase, where a total of 3 concepts were generated. Each concept contained a sum of design choices that indicated the physical design and user interaction features of that concept. In order for that to happen, a plethora of design choices was generated through a morphological diagram, based on the certain requirements that were derived from a requirements table. After evaluating the 3 concepts by comparing with each other through a Trade off Matrix and the input that was given from the clients, the chosen concept indicated a battery that could be taken in and out a battery base easily and securely in order to be used as a speaker for entertainment purposes and as a powerbank for the user's other devices.

Figure 1 - Chosen Concept User Interaction Features (Rappos, 2022)

Figure 2 - Chosen Concept Battery Design (Rappos, 2022)

Further refinement was done in the Realization Phase. A total of 11 physical prototypes and 3 focus group testings were made in order to define the product's key characteristics. These characteristics were the battery system's specifications (ex. Battery capacity), the battery housing's dimensions, formfactor and the positioning of some of the electronic components in the battery housing that were important for the User Interaction. Those specifications would also influence the design of the Battery Base, as a support part. The User Interaction was defined through the prototype testing, collaborative sessions with the clients and also the use of an FMEA table (where solutions for potential failures are derived). That way the list of electronic components that need to be housed is derived and it is what makes the User Interaction features possible. Later, the assembly design took place for the battery and battery base. Materials, Manufacturing Methods and Durability were taken into account during the making of the different assembly choices. The goal was to define a feasible to manufacture assembly that satisfies as many wishes and requirements as possible. The result was a preliminary assembly for the battery and battery base. In order to get that, an evaluation similar to the Ideation Phase took place (input of the clients and use of a Trade-Off matrix) that compared 3 assembly designs for the battery to each other.

Figure 3 - Final Design Render. (Rappos, 2022)

Although the key characteristics were defined, it is important to note that the result was a preliminary design. Also, more target group testing should be made, as there were limitations to the number of participants due to time (each testing included approximately 10 people, from the international university student demographic. It would be best to include a lot more people from different demographics also). The experience and knowledge of the designer did not allow for a detailed, ready for production assembly, as important components such as materials, specific electronic components, surface detailing for the chosen manufacturing processes need further definition.

The preliminary result was concluded to answer the research questions and satisfy the requirements for the most part. For example, details like cost and durability that are reflected in the requirements could not be considered as fully satisfied because of the data that is needed from a more detailed assembly. Most of the design decisions were evaluated approximately, through the critical thinking of the designer and supervisor, but most of them (apart from the focus group testing data) need to be revisited, with a more specific metric based evaluation, that does not rely as heavily on assumptions. So finally, more focus group testing should be added, also for the added features that were mentioned (powerbank, speaker), more assembly design choices should be made (the approach of digital generative design could help) and that would be a promising continuation and refinement of the work that has been done.

References

1. Swugo. (2022) Electrifying urban micro mobility. (n.d.). Retrieved July 18, 2022, from https://www.swugo.com/