

## ORIGINAL ARTICLE

## INDUSTRIAL DESIGN MODELING FOR A GLUCOSE SENSOR DEVICE

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## ABSTRACT

This paper presents the methodologies and the systematic approaches in the industrial design development process to incorporate aesthetic and affective elements in a Glucose Sensor device. EQUID (Ergonomics Quality in Design) design approach was applied where users' requirements were identified in early design stage utilizing Kawakita Jiro (KJ) method. Benchmarking and trend analysis were also conducted in early stage to understand market trends, compare features and faults in existing product in the market, at the same time finding opportunities for improvement in our own product. The development of the shape of the Glucose Sensor device, the color chosen and the branding profile creation were also discussed in the paper. Several design concepts and prototypes have been developed and user's emotions towards each concept in focus group have been captured. The survey was carried out at the end of this paper to assess the design effectiveness.

**Keywords:** glucose sensor, pleasurable, affective, industrial design

## INTRODUCTION

The Glucose Sensor device is a non-invasive version of glucose sensor utilizing NIR (Near Infra-Red Spectroscopy) for medical application that provides diabetes screening as an early symptom in diagnostic. It can provide glucose measurements painlessly, without a blood sample or finger pricks, within a few seconds.

Current practice of glucose sensor requires a blood draw through finger pricks for each test, which causes pain and inconvenience. Besides that, each test also requires a new test-strip, contributing to the recurring cost of such a device. Therefore, the Glucose Sensor device is developed that aims to overcome the issues addressed.

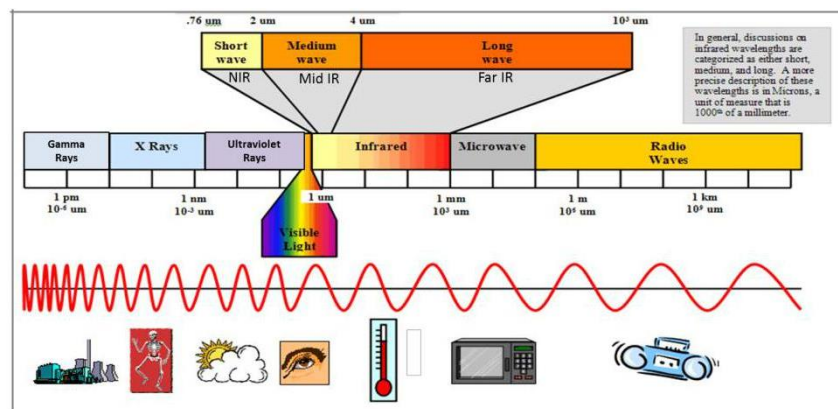


Figure 1 - Electromagnetic spectrum



Figure 2 - One of the current practices of glucose sensor (Source: [http://mu-varna.bg/EN/Pages/glukozni\\_senzori.aspx](http://mu-varna.bg/EN/Pages/glukozni_senzori.aspx))

Medical devices are typically regarded as serious or boring tools due to their inherent features and purpose. Some people may even be intimidated by medical devices due to their past experience. In our effort to change the general perception on the medical devices, we have taken a step ahead to incorporate human factors and pleasurable emotion in the Glucose Sensor device outlook by applying Ergonomics Quality In Design (EQUID)<sup>4</sup> design approach. EQUID is an International Ergonomics Association (IEA) initiative to promote the integration of ergonomics into the design process where the HFE aspects and concerns are addressed during the feasibility stage, conceptual sketches and technical discussions during the design development cycle.

During the ID development stage of the Glucose Sensor device, some tools which commonly used in the conventional Product Development Process (PDP) were used to address Emotional Design and Product Aesthetics' concerns and opportunities such as Understanding User Needs through i.e Kawakita Jiro (KJ) Analysis and Benchmarking. The following sections describe the activities carried out to institutionalize ergonomics quality in Industrial Design in designing a product that meet user's affective requirements.

## USER REQUIREMENTS

There are some rules and requirements to comply when designing a device for medical use. In 2000, the FDA's Center for Devices and Radiological Health (CDRH) published its guidance entitled Medical Device Use Safety: Incorporating Human Factors Engineering in Risk Management relating human factors, ergonomics, and usability methods directly to the process of risk management in device design. Besides the necessary requirements and standard rules, the users' needs are also important to the Glucose Sensor device design. It is important to design a product with specifications that meet customer demands. Initial product specifications can be generated through competitive benchmarking and market analysis against successful products in the market. These aim to understand market trends, compares features and faults in existing products in the market, at the same time finding opportunities for improvement in the development of own product. By doing so, initial user requirements can be established which will act as the design guideline to be implemented in the design which will eventually be a final, user centred product. In most cases, the initial user requirements can be very broad and these user requirements can usually be grouped separately into functional requirements and affective requirements.

### Contextual Inquiry

At the preliminary stage of the EQUID process, initial design specifications for the product were established by translating the user needs into design requirements. This will ensure the design meets customers' needs and expectations. User needs, in other word, Voice of Customer (VOC) were gathered through Contextual inquiry (CI). CI is a human factors research method that combines the questioning and observation of users within the environment of use. It has its roots in ethnography and aims to collect contextual information by observing people in their work or living environment<sup>7</sup>. Figure 3 illustrates the working condition when CI conducted at one of the hospital. The VOC were then prioritized using KJ analysis. The analysis result showed shape is the most important industrial design criteria for the Glucose Sensor

device with the highest scoring, followed by size and color.



Figure 3 - Working condition in lab of a hospital

### Benchmarking and Trend Analysis

After the design requirements had been identified using KJ analysis, trend analysis and design benchmarking were performed as well to benchmark against similar existing products in the current market to determine the targeted affective keywords. Affective requirements are those pertaining to the look and feel as well as the pleasure a user experiences when using the product. Affective requirements are becoming more important in product design nowadays as they drive the emotion of the users when using the product. The affective descriptors captured from the benchmarking that related to the ID of this Glucose Sensor device including clean and classy. This was the opportunity for us to improve from the existing market products by adding new affective descriptors to the new ID of this Glucose Sensor device. Expensive and high-tech were the new descriptors that added to the design requirements to change the general perceptions on the Glucose Sensor device. Other than that, from the product benchmarking, knowing that current design trend for the medical devices are white and blue color, and the surface finishing is glossy surface.



Figure 4 - Benchmarking Products

## ID DESIGN

After design requirements had been identified, a few design concepts had been developed and Figure 5 illustrates the final ID of the Glucose Sensor device.



**Figure 5 - Final ID design of Glucose Sensor device.**

The size of the Glucose Sensor device is significantly driven by the components of the device. It has the limitation on tailoring the size and adjustment. In order to be appeared as clean and classy product, minimum profiling was done on the surface design. The product appears in rectangular shape, embedded with orthogonal elements. Orthogonal is one of the company design DNA elements. Design DNA holds the core design principles and value of a brand with instant recognition of a mark of replicated quality as an extension of the product family, characteristic of the origin<sup>3</sup>.

Color selection also plays an important role in product pleasurable and aesthetic design as it drives the emotion of the user when they interact with the product. Using the design element of color in right ways not only contributes to the product's aesthetic, but also helps the user understand intuitively how the product should be operated<sup>5</sup>. Based on the product benchmarking findings, current design trend for the medical devices are white and blue color. In Glucose Sensor device industrial design, white, black and grey were selected. White has a strong connotation of cleanliness/sterility and

purity; therefore, it's very appropriate in a medical setting<sup>2</sup>. While black associates to elegance, mystery, expensive<sup>9</sup> which will create an expensive and elegance feel to the Glucose Sensor device. Grey was selected for the LCD screen frame to separate the product body and the display panel that aims to draw attention from the users on the information and user input area.

## USER CENTERED DESIGN

In this section of the development, the ID was evaluated and reviewed with the aim to satisfy the user requirement set forth in the previous process. As we know, ID is more on the appearance and the outlook of a product, however, it correlates with some functional features as well. The traditional design rule is always form follows function. And hence, the functions and the context of use of this Glucose Sensor device need to be captured as well. By establishing the user model, the goal of the design in the context of human factors and ergonomics could be clearly stated. This could be accomplished by defining the user scenario and personas whereby task-centric scenarios were put under careful consideration and how design features could affect user interaction. Two different personas were studied in this case: i) nurse; ii) patient. These two user categories are different due to their purpose of use and experiential level. The interaction of the user with the product were scrutinized and understood in detail by the user task-centric method. Also, their expectation on the ID of this product could also be addressed. In this process, the ID design was reviewed and iterated based on the developed user model and criteria.

**Table 1: User Task Model of Glucose Sensor Device**

Type of User	User Goal	Task	Context of Use	ID Interaction
Persona 1: Nurse	To get the glucose level reading of patients fast and safely	Instruct patients to insert their thumb into the thumb module for measuring	Operation	Thumb module profiling
	To get accurate glucose level reading	Take reading from the display screen	Operation	LCD location
Persona 2: Patient	To get glucose level reading fast, painless and safely	Insert their thumb into the thumb module for measuring	Operation	High performance and reliable appearance



## DESIGN ASSESSMENT

### Method

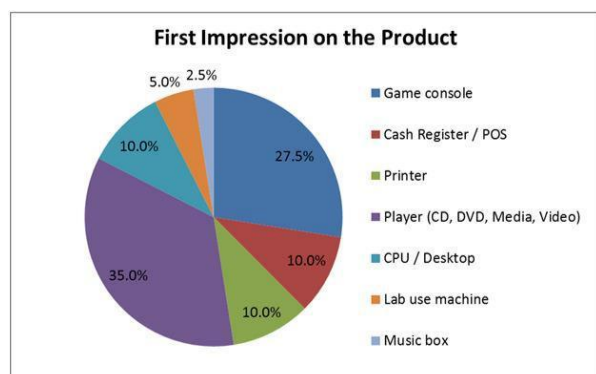
The final industrial design of the Glucose Sensor device was given to the two groups of personas as mentioned above. Upon request and without any prior briefing in relation to

the product, they wrote down their first impression on the Glucose Sensor Device, with three affective descriptors of the ID design. Table 2 below shows some examples of affective descriptors given to the respondents as reference and they were allowed to write other descriptors which were not in the table. Thirdly, color preference also surveyed too

**Table 2: Example of Affective Descriptors**

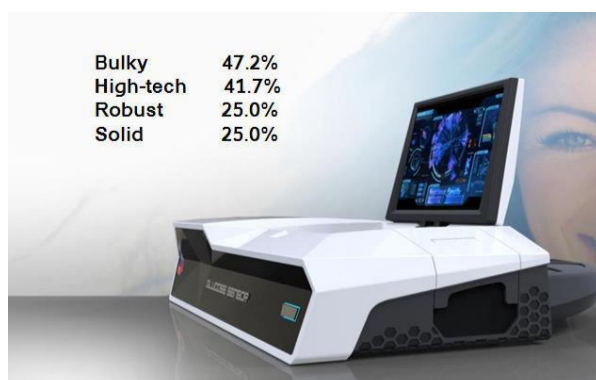
High Performance	Repulsive	Cute	Bright	Crude	Ugly
Clumsy	Weird	Simple	Curvy	Solid	Stylish
Robust	Elegant	Classic	Powerful	High Technology	
Fashionable	Sleek	Fine	Dull	Pleasing	

## RESULTS



**Figure 6 - First impression on the product survey results.**

There were total 36 correspondences and 35% of them think the product looks like a media player at their first glance. Second highest score is game console and followed by CPU and printer as illustrated in Figure 6. Figure 7 below shows the survey results on the top four affective descriptors. 47.2% of the correspondences think the Glucose Sensor device is bulky, followed by high-tech with 41.7%, robust 25% and solid 25%.



**Figure 7 - First impression on the product survey results.**

On the color preference, 55.6% of the users preferred light blue color for the Glucose Sensor device, and 30.6% preferred light green color. Only 16.7% of the users chose black color. The reason of setting options for light blue or light green is due to those colors has soothing and calming effect. Figure 8 demonstrates the

Glucose Sensor device with light blue and light green color.



**Figure 8 - Light blue and light green color options on Glucose Sensor device.**

## FINDING AND DISCUSSIONS

Majority of the users think the Glucose Sensor device is a media player at their first glance. This is due to the LCD display on the device. In other words, the product has successfully changed the perception of the users on the traditional medical device appearance. It does not appear boring and threatening to the patients. It looks like an entertaining and high-tech device. Due to the components inside the Glucose Sensor device, the entire product has the limitation on reducing the size. Hence, it gives the impression to the users that the product is bulky. However, the users think the product is high-tech and robust, this had met the design objectives. Majority of the users prefer the device to be in light blue color. This has becomes a reference for us for the future improvement activities. Figure 9 illustrates the actual prototype of the Glucose Sensor device.



**Figure 9 - Actual prototype of Glucose Sensor device.**

## CONCLUSIONS

The need to address Emotional Design and Product Aesthetic aspects for Industrial Design demands structured methodologies which the focal issues normally revolves around visual fluency and perceived hedonic quality while primarily satisfies the usefulness and ease of use.

The systematic process, in conformance to EQUID framework, supported by an empirical scientific checklist helped designers to capture user requirements both functional and affective design. With new user requirements addressed, the new product is aesthetically more appealing and more likely to fulfill emotional attributes.

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