



# The Design-Related Quality Factors of Smart and Interactive Products

## From Industrial Design to User Experience and Interaction Design

Yichen Wu<sup>(✉)</sup>

China Academy of Art, Hangzhou 310000, China  
wuyc@caa.edu.cn

**Abstract.** The connected objects, also named smart products or smart device, are permeating into people's lives and changing their behaviors and habits. They are updated from normal products by implanting electronic chips and system, connecting to the Internet or other devices, and users have to operate them through the physical the digital interface. Thanks to the popularity of smart products, the economy is increasing, the relevant market is expanding, and the consuming habit of society is evolving. Design as the force for innovation was given greater responsibility to the development of the smart product at this time. Nowadays, many design disciplines are involving smart objects, e.g. industrial design, interaction design, user experience design, service design. However, these interactive, technology-related products have high failure rate actually, most of them failed at the concept phase. These failures lead to design waste. Thereby, how to design a smart product with high quality of user experience is the critical question. The user experience quality in this context not only includes the form and function which focused by industrial design but also included the interactive mode, the emotional perception, and so on. Consequently, to get this success, to enhance the quality is the method to make the smart object stands out from the crowd in the competition. Thereby, this research attempted to demonstrate the specific factors of quality in the smart product in theoretical models by analyzing the complexity of the smart objects and discussing the quality of each part of the smart product.

**Keywords:** Smart objects · Quality · Design

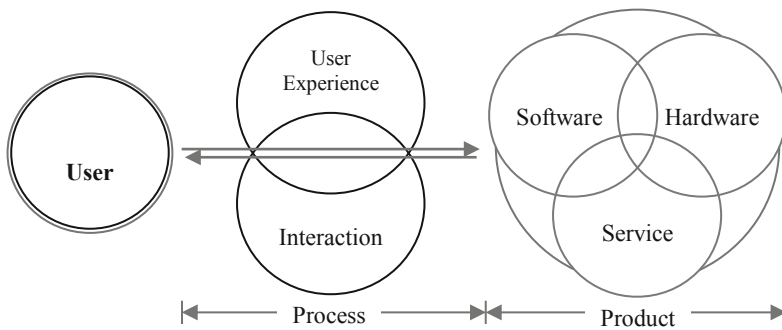
## 1 The General Quality of Connected Objects

Connected objects are the products with interactivity, the experience of the final user determines the user viscosity, which is whether the user will continue using the product or not, and it determines the value of the product, the value not only to the user but also the designer, the producer. From this perspective, to occupy the market and be favored by the users is the everyday success for a connected object. Consequently, to get this success, to enhance the quality is the method to make the connected object stands out from the crowd in the competition.

Quality is a complicated concept, and it could be interpreted as a predictable degree of uniformity and dependability, at low cost and suited to the market [1]. From the

definitions of quality in diverse context, it is a standard to something, and there is no specific definition of the quality for connected objects. Thus, I tried to figure out the quality of connected objects by defining the factors that impact the quality of the products, and all the factors were in the context of design.

When we elaborate on the entire process of a connected object with users, the connected object is collecting the data from the environment or the user's body in a subtle way. From the user to the need, the quality of the connected object covers the product and the interaction process, and user experience is the final result by the combination of the product and the interaction process with the user. Besides the interaction process, from the product attribute's point of view, the connected object is composed of hardware, software and service system. The hardware and software constitute the tangible product, in which the hardware is the external form and the electronic components, while the software is the internal platform for information processing, graphics interface, the audio interface is the external performance for the software. The service system is invisibly relatively to hardware and software, and it is a designed system to serve the user with functions. Based on the model (Fig. 1), I conducted the investigation of quality factors from the three aspects in a design context, including the product, the interaction and the experience, to define the factors those impact the quality of the product itself and the quality of interaction and user experience.



**Fig. 1.** The attribute of components in connected objects

## 2 The Definition of Quality About the Hardware, Software and Service

The product quality in this research section is the quality of hardware, software and the service. With the investigation of the constitution of the product in a connected object, the concept of hardware is the physical product. With the literature review, there are few references discuss the quality of the physical part separately. However, there are abundant studies on the quality of software and service. By the literature review, the concept of product quality shows the diversity in a different context, and it interpreted depends on the products' attributes. Talking about the value, a quality product or service

is one that provides performance at an acceptable price or conformance at an acceptable cost. David (1984) also presented the eight dimensions of quality; they identified as a framework for thinking about the essential elements of product quality, including:

- Performance
- Features
- Reliability
- Conformance
- Durability
- Serviceability
- Aesthetics
- Perceived Quality

The software is the implanted program of the digital, interactive product, and it is the system for the coordination and control of smart and connectivity components in a connected object by the user's operation. Through ISO 25010, there are eight characteristics of the quality of the software:

- Functional Suitability
- Performance efficiency
- Compatibility
- Usability
- Reliability
- Security
- Maintainability
- Portability

The service in this context is the service for the information system, which is embedded in the connected object. The definition of service quality revolves around the idea that it is the result of the comparison that customers make between their expectations about service and their perception of the way the service has been performed [3]. The service quality also be defined as the match situation between prior expectations and experience [4]. The factors include Ease of use, Appearance, Personalization, Information, Responsiveness, Communication, Security and Reliability. Based on these various definitions of the service quality factor, I merged similar factors and removed the factors that indicated to the specific service form, such as the linkage and content in the website service quality. As a result, there are eight factors of service quality:

- Ease of use
- Appearance
- Personalization
- Reliability
- Communication
- Security
- Efficiency
- Support

### 3 The Quality of the Interaction and User Experience

The interaction and user experience of the connected objects have a delicate relationship from their properties. First is the causal relationship between them, UX as a momentary, primarily evaluative feeling (good-bad) while interacting with a product or service [5]. Thus, the interaction between the user and the products generates part of the UX, which is the feeling in the process of the product using. Meanwhile, the interaction and UX have large part crossed and overlapped, and the interaction is a series physical actions which create the most of the user experience, and to use the product is to inter-act with the product. By these reasons, the quality factors of interaction and user experience bound to overlap, and the method to derive the quality factors of them was to collect the factors' definitions by literature review firstly, then integrated them through the specific interpretations.

Talking about the interaction quality, the ISO/IEC 25010 define the quality in use is the degree to which a product or system can be used by specific users to meet their needs to achieve specific goals with effectiveness, efficiency, freedom from risk and satisfaction in specific contexts of use. When we combine to the context of design, the interaction design quality will be measured through two dimensions: user interface quality and communication tools quality, where the measures of two dimensions are adapted from several standard scales [6–8]. About the user interface, the quality factors include Effectiveness, Productivity, Efficiency and Error Safety. Additionally, by the investigation of other relevant research [9–13], and combined the quality factors and models of them, the quality factors of interaction could refer to trustability, re-source-limitedness, usability, ubiquity.

About the quality of user experience, there is still no accurate description of it yet. UX is still a concept that is being debated, defined and explored by researchers and practitioners [14]. Some of the research had worked out the possible factors of the user experience quality, which includes Satisfaction, Involvement, Affordance, Coolness, Enjoyment, and Hedonicity [15]. Most of the references argued the UX has an undeniable connection with Usability, and it appears in almost all research on the quality of interaction and user experience. Nevertheless, usability is not equal to the UX; By the diverse opinions, the usability is part of the UX, and it intends to be the matter of the product's functional part, there are other factors of UX, such as the experience of the brand. Peter Morville made a point of the User Experience Honeycomb in 2004, the user experience quality issues are defined into the seven factors:

- Useful
- Usable
- Findable
- Desirable
- Credible
- Accessible
- Valuable

## 4 The Quality Factors Model of Connected Objects

The connected objects' quality factors model was built from the design's point of view. To define the connected objects' quality factors precisely with the research context, I used four steps to deduce the final factors. Firstly, by the various but partially repeated definitions of the quality characteristics for product, software, service, interaction and user experience those listed before, I tried to integrate the factors in two-part, one is the part of the connected object; another one is the process which including the interaction and the experience of the user. The integration of the factors according to the interpretation of the definitions, then to reorganize them by the methods which involved merging similar definitions, eliminating overly broad concepts and reclassify the section of the factors.

Secondly, with the new factors of both the product and the process, I intended to modify them by a principle, which is either the factor is the inherent attribute of the product or it exists when users involve. With this principle, the factors were unique and more precisely in each part.

Thirdly, I redefined each factor based on the referred interpretation.

Fourthly, I produced the final model of the quality factors for connected objects and demonstrated it.

Specifically, in the integrated phase of the product, there were six factors kept the original attribute in their parts, besides the support, personalization, communication of the service quality and the port-ability of the software quality, I added the durability and ergonomics into the quality factors of hard-ware. The physical product requires the human factors and ergonomics, to make the product more suitable for people, ergonomics is the study of the interaction between people and machines and the factors that affect the interaction. Meanwhile, the durability is the ability of a product to perform its required function over a lengthy period under normal conditions of use without excessive expenditure on maintenance or repair.

Most of the factors have similar explanations, such as reliability, security, performance and maintain-ability. They were merged from similar factors, and they converted into the common factors of two or three sections. Additionally, based on the combination of the definitions, I expanded the usability, compatibility, functionality and perceived quality from two sections to three sections, because all of them fit for the three aspects of the connected object. For instance, as a discussion before, usability involves almost every part in the using of the products by the users, it related to the software interface, hardware interface and the service system. Meanwhile, compatibility is the characteristic to maintain consistency of internal, external components of the product and the interaction in the usage of the service. Perceived quality refers to all the forms which can be perceived by the users of the products. In this integrate process, the aesthetics is a critical factor for both hardware and software.

In another part of the first phase, the integration of the process employed the same methods. Based on the previous interpretation of the definitions, two factors maintain original states, in which ubiquity belongs to the interaction, while the value belongs to the user experience. Utility, desirability, accessibility and reliability were generated from their synonyms which studied by literature reviews before. Usability was an essential factor in the interaction part, it was synthesized from diverse specific factors both in the

parts of interaction and experience, such as effectiveness, efficiency, and it became the common factor of the two sections. The model of this part was demonstrated in Fig. 3.

After the integration, in step two, because there were some repetitive factors both in product part and process part and some factors of the product requirements to realize their value by the participation of users, thus I modified some factors according to the user's point of view based on the integration models. The standard to distinguish these two parts was whether the factor involves the user or it is the property of the product itself. There

**Table 1.** The definitions of the product part

Factors	Hardware	Software	Service
Performance	<i>Primary operating characteristics</i>	<i>Time consumption, resource utilization, parameters' limitation</i>	/
Functionality	<i>The functions that meet stated and implied needs as in physical way</i>	<i>The functions that meet stated and implied needs in digital way</i>	<i>The functions that meet stated and implied needs in the service process</i>
Security	/	<i>Information and data protection in the system</i>	<i>To protect the users' perceived security and privacy</i>
Aesthetics	<i>The shape, color, material, finishing</i>	<i>The beauty of User interface</i>	/
Ergonomics	<i>The measurements between human and products</i>	/	/
Durability	<i>The lengthy period for using</i>	/	/
Maintainability	<i>The speed, courtesy, competence of repair for the product</i>	<i>The effectiveness and efficiency of the improvement and update for the system</i>	/
Compatibility	<i>The form and operating characteristics match established standards</i>	<i>The ability of exchange information with other systems</i>	<i>The operating and engagement follow the established standards of the product</i>
Personalization	/	/	<i>To create function and interface for individuals</i>
Portability	/	<i>The software can install or transferred from one product to another</i>	/
Support	/	/	<i>The technical help and advice from the service provider</i>

were four modifications in this step, reliability and usability in the product part were merged into the same factors in the process part; perceived quality and communication were moved from product part to the process part. All of these four factors either are the feeling of the user or need the participation of users.

In step three, I defined every factor in all aspects of each part, including the hardware, software, service aspects of the product part (Table 1). And the final model of quality factors for connected objects' design is demonstrated in Fig. 2.

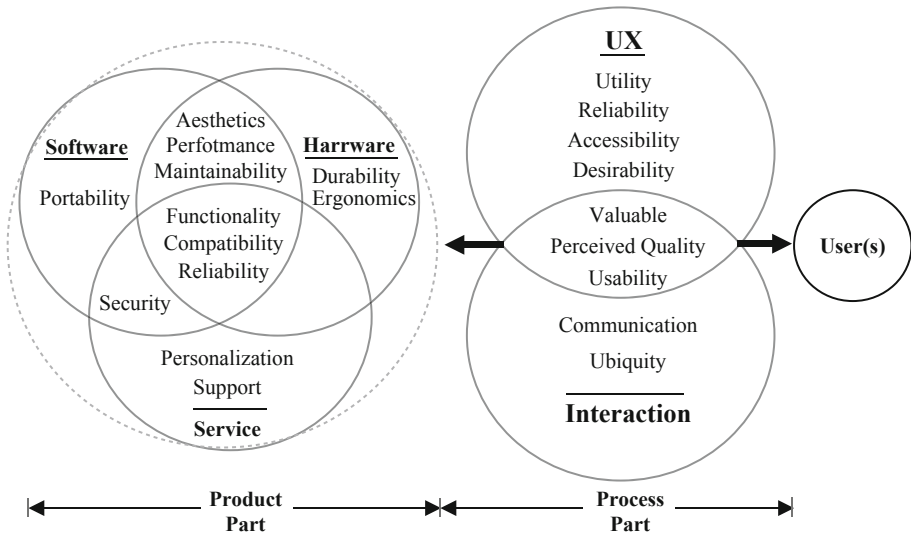


Fig. 2. The final model of quality factors for connected objects' design

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