# The EQUID approach: improving ergonomics quality in product life cycle

Karen LANGE-MORALES[1], Gabriel GARCÍA-ACOSTA[1,2] and Ralph BRUDER[3]

[1] *School of Industrial Design – MIMAPRO Research Group, Universidad Nacional de Colombia, Bogotá, Colombia*
[2] *Centre de Disseny d'Equips Industrials, Universitat Politècnica de Catalunya, Barcelona, Spain*
[3] *Institute of Ergonomics, Technical University of Darmstadt, Darmstadt, Germany*

**Abstract.** This paper presents the rationale behind the EQUID (Ergonomics Quality in Design) approach. The EQUID approach is a model that integrates two complementary processes. It tackles the requirements for addressing user issues according to the product life cycle, and it deals with the requirements to ensure the quality of addressing user issues in product design. The model was built upon the following aspects: challenges of product design and development (PDD) (i.e. uncertainty, complexity and consistency), PDD related to product life cycle, requirements related to organizational culture, requirements related to the design process, and stakeholders involvement.

**Keywords.** Ergonomics, Product Design, Quality, Product Life Cycle

## 1. Introduction

Ergonomics Quality in Design (EQUID) is an initiative of the International Ergonomics Association (IEA) to help the public make more informed decisions about the ergonomics quality of products, and to promote the integration of ergonomics into the design process. The first version (2008) was constructed by experts in the name of IEA over several years (2000-2007). This version called EQUID Design Process Requirements (v.1.11) was submitted for feedback from professionals that gave a positive judgment on the initiative. They recommended that the document should be easy to understand, and that case studies to illustrate its implementation should be developed. A provisional version called "The key requirements of the IEA EQUID Process" was published as an annex in 2011 (Nael, 2011). Parallel to the development of EQUID, the standard ISO 9241:210:2010 (Ergonomics of human-system interaction -Part 210: Human-centred design for interactive systems) (ISO, 2010) was launched, whose objective overlapped with the EQUID initiative to some extent. Based on the recommendations done to version 1.11, and looking for a differentiation with the ISO standard, the EQUID committee took the decision to develop a document complementary to existing standards, designed for a broader audience and in this way promoting broader access.

## 2. Methods

A Delphi study (Linstone & Turoff, 1975) was conducted. Experts on ergonomics, usability, and user experience (UX) were asked about the benefits of HFE in PDD, which questions were frequently asked by different stakeholders involved in the process, and the different roles that HFE experts could play along the product life cycle (PLC). Complementary to the Delphi study, several successful product developments were chosen and analysed as case studies. These case studies varied in complexity, by economic sector, geographical location of development and use, organizational conditions, and HFE implementation strategies. Also, in-depth interviews with stakeholders responsible for the whole product development and for the incorporation of HFE issues were carried out.

Based on the Delphi study and the analysis of the case studies, several challenges of PDD were deduced. In order to address these challenges, a model based on the engineering PLC (Cao & Folan, 2012; Riba i Romeva, 2002; ) was constructed, taking into account how HFE issues are related to the whole PLC (García-Acosta et al, 2011). The design requirements considered in the EQUID v1.11 version were analysed and organized into two groups, and were thereafter related to the PLC stages. Finally, stakeholders and stakeholders' questions were integrated into the model.

## 3. Results

The EQUID approach is a model based on three inputs: PDD challenges, PLC, and the requirements for ensuring ergonomics quality in the design and development process for products and services. The model includes seven parts: PLC stages, stakeholders' involvement, stakeholders' questions about HFE, required processes for ensuring ergonomics quality in design, required documents, methods for addressing HFE issues, and the relationship with standards. Three case studies illustrate the model, emphasizing different aspects of the model.

### *3.1 Challenges in PDD*

Designing and developing a product involves facing at least three challenges: dealing with uncertainty, dealing with complexity, and how to maintain consistency along the whole development cycle. Guaranteeing ergonomics quality along the whole product life cycle is one way of contributing to solve these challenges.

Product design implies dealing with values, desires and expectations, and all these are future oriented. This involves dealing with uncertainty. Future studies (foresight) offer tools for 'building the future' in a range of possibilities and probabilities. Probable futures are built as scenarios of use (Fulton Suri & Marsch, 2000), where technologies under development for future technologies can be projected. This process allows the development of new solutions to human needs and demands. Each product has a different technological evolution, but in all foresight exercises, it is necessary to take into account user issues, and in this particular case, future expectations in all possible dimensions (physical, cognitive, emotional and even spiritual). The physical dimension tends to be more predictable and pre-established in a time line. On the contrary, cognitive, emotional and spiritual dimensions tend to suffer greater transformations in time, locally and globally speaking. Tools such as ethnographic studies and the participative construction of future scenarios with people, are effective tools for dealing with cognitive, emotional and spiritual issues. Once understood, these can be incorporated with quality in future products.

PDD requires many aspects to be considered: technical, economic, human, logistic, commercial, etc. Depending on a product´s complexity, these factors are managed by different stakeholders, and these stakeholders have the responsibility of taking the best

decision regarding their specific competence. The problem is that each aspect involves challenges for the product design, and often conflicts arise when making decisions about the product. However, these conflicts can be solved successfully when all stakeholders involved in PDD understand their common goal: to deliver a successful product to the market, and a big part of this success relies on the quality of handling user issues. Reaching this goal requires that stakeholders come to a consensus, not just in a part of the design process but along the whole product life cycle.

Complexity has different perspectives. On the one hand, it is related with the need to align the needs and expectations of people involved in the process and the product's technical viability. On the other hand, complexity has to do with understanding user needs and expectations, and further on translating them into a technical language that can be incorporated as part of the product's functions, structure or materials just to give some examples. A successful management of complexity helps to reduce uncertainty.

Consistency along the whole PLC is the third challenge. Depending on the product, its development can last from a couple of months to years. To ensure that the defined requirements regarding user issues are maintained along the whole PLC means ensuring the quality of a product from an ergonomics perspective. These demand strategies for verifying that the questions of the stakeholders are taken into account and that the decisions taken are kept when advancing from stage to stage.

### *3.2 Product life cycle stages*

Stages in the PLC vary depending on each product and production system, and there is no standard specifically related to stages. For the EQUID model seven stages were defined: vision, concept, development, production, transfer, use / maintenance, and final disposal. Vision is the most strategic stage as it is there where identity and innovation of the new product is determined. It requires a consensus of the different stakeholders of the company or organization responsible for the development of the product. A company's policy and identity are directly related to the product's character, looking for identification with the enterprise and differentiation with the competence. Different trends that can be adopted from a HFE perspective play an essential role (e.g. inclusive design, usability, customer centred design, etc.)

Concept is the stage where different interests (related to human or technical aspects) are established in the form of experiences, suggestions, variables, requirements or determinants to be taken into account in the product development. Here the different perspectives on user issues are accumulated and put into equal conditions as economic, formal or technical demands. Development is understood as the phase where the whole design (detail) of a product is solved. It is a crucial stage for ensuring that user issues are taken into account. Most of usability trials are done during this stage.

Production refers to the stage where the product is manufactured. Here the HFE aspects are related not to the end product, but to the production means. In complex companies this theme is tackled by an entirely different department (e.g. responsible for occupational health). However, if aspects regarding design for manufacturability are taken into account during the previous stages, the production stage (i.e. the production conditions) will be favoured.

Transfer refers to the stage where the product acquires a technological situation concretely located in an existing supply and demand relationship. It includes distribution logistics, promotion places and strategies, purchases-sales, and the incorporation into the final user settings. After the product is bought and installed, the use / maintenance stage becomes evident if user issues were dealt with appropriately. The success or failure of a product depends greatly on the quality of addressing user issues. The last stage of PLC

refers to final disposal. This stage has not been particularly related to user issues, although more and more organisations are implementing actions towards environmental and corporate responsibility. From a HFE perspective, it is very important that users know the appropriate handling of the product when it is obsolete.

*3.3 Requirements for ensuring ergonomics quality in design*

These requirements were organized into two groups and are based on EQUID version 1.11 (see annex in Nael, 2011). They constitute the core dimension of EQUID. On the one hand, requirements related to the organizational culture ensure the quality of HFE issues management during PDD. On the other hand, requirements related to the design and development culture look to ensure the quality of the understanding of user issues and its translation into product design requirements.

Requirements related to organizational culture include two processes: organisation management and documentation. The objective is to ensure the quality of managing (involving / dealing with) HFE issues during the PDD process. Management commitment; quality policy, quality objectives, and organisational planning; responsibility, authority, and communication; management control; and human talent competence, awareness and training regarding HFE, are the key aspects of organisation management. Some of these sub-processes concentrate on the first PDD process, while others (e.g. like management commitment) cover the whole PLC. Regarding documentation, five sets of documents have to be created and updated: 1) user requirements, 2) design process / decision making, 3) final ergonomic evaluation, 4) ergonomics for manufacturing report, and 5) user satisfaction reports.

Three processes are considered in the requirements related to the design and development culture: understanding user issues, reviews, and evaluation. The goal of these processes is to ensure the quality of the understanding of user issues, and the translation into design requirements. Understanding user issues includes at least dealing with the following topics: target user(s), including their characteristics and variation limits; intended context of use, including possible variation limits and consequences for the user requirements; user goals that have to be satisfied by the product (activities, influence factors, use scenarios); user satisfaction reports of previous or similar products; post-sale support planning; performance criteria for product ergonomics; relevant user issues related to health and safety; and ergonomic performance criteria for manufacturing.

*3.4 EQUID matrix, location of stakeholders, and location of stakeholders' questions*

By relating PLC stages with quality assurance processes, a matrix was built. In this matrix every specific requirement was located. The matrix allowed the location of stakeholders involved, including managers (general, product, project), marketing staff, designers, HFE specialists, engineers, production workers, sellers, users, etc. The matrix was 'energized' by adding the typical questions of the stakeholders. Figure 1 illustrates the EQUID matrix with the location of stakeholders' questions.

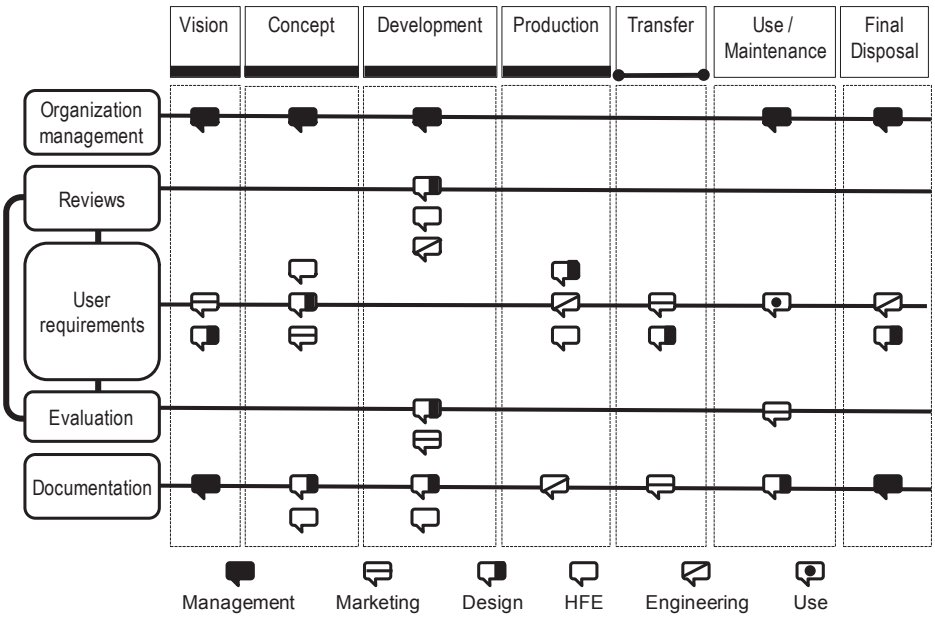


*Figure 1. EQUID Matrix relating PLC stages, requirements for ensuring ergonomics quality in design, stakeholders, and stakeholders' questions.*

## 4. Discussion and Conclusions

To understand why this is important and how ergonomics can be incorporated into quality in PDD, one has first to understand how an idea becomes a product. To understand how an idea evolves into a product, one has to first address the challenges involved in PDD. Therefore, the EQUID approach first tackles the challenges of developing a product. After understanding the challenges, the dimensions of time and space are added, in order to look into the design and development process along a time line. This is done by introducing the concept of PLC. Once the design and development process is understood along the PLC it is possible to address the purpose of including ergonomics at each phase. However, knowing the goal of each phase regarding ergonomics is not enough to guarantee the quality. That is why five processes, that constitute the central elements of the EQUID approach are presented. On the one hand, two of these processes are related to the organizational culture; on the other hand, the other three are related to design and development culture. The complementary performance of all these processes along the whole PLC is the key to including ergonomics successfully into PDD. Therefore the phases of PLC and the mentioned processes are related in a framework, summarizing the whole concept. Finally, the approach is dynamic by including the stakeholders and competence areas involved in the process, understanding their roles and frequent questions. Altogether, the PLC, processes and stakeholders are aligned towards one single goal that guarantees ergonomics quality in product design.

**References**

Cao, H., & Folan, P. (2012). Product life cycle: the evolution of a paradigm and literature review from 1950–2009. Production Planning & Control: The Management of Operations. 23:8, 641-662, DOI:10.1080/09537287.2011.577460

Fulton Suri, J., & Marsch, M. (2000). Scenario building as an ergonomics method in consumer product design. Applied Ergonomics, 31, 151-157.

García-Acosta, G., Lange-Morales, K., Puentes-Lagos, D.E., Ruiz Ortiz, M.R. (2011). Addressing Human Factors and Ergonomics in Design Process, Product Life Cycle, and Innovation: Trends in Consumer Product Design. In Karwowski, W., Soares, M. and Stanton, N. (Eds.), Handbook of Human Factors

and Ergonomics in Consumer Product Design: Methods and Techniques. (Chap. 9, pp. 133-154). Boca Raton: CRC Press Taylor & Francis.

ISO 9241-210:2010 - Ergonomics of human-system interaction -- Part 210: Human-centred design for interactive systems.

Linstone, H. A., & Turoff, M. (1975). Introduction. In H. A. Linstone, & M. Turoff (Eds.). The Delphi method: Techniques and applications (pp. 3-12). Reading, MA: Addison-Wesley Publishing Company.

Nael, M. (2011). The IEA EQUID Template for Cooperation between Product

Designers and Ergonomists. In Karwowski, W., Soares, M. and Stanton, N. (Eds.), Handbook of Human Factors and Ergonomics in Consumer Product Design: Methods and Techniques. (Chap. 18, pp. 261-272). Boca Raton: CRC Press Taylor & Francis.

Riba i Romeva, C. (2002). Ciclo de vida y recursos asociados. In Riba i Romeva, C. Diseño Concurrente (pp. 20-28). Barcelona: Edicions UPC.