Product Functionality Evaluation Methods and Applications

Mohamed Shohdy Ahmed

Lecturer, Metal work and Jewelry Department, Faculty of Applied Arts, Helwan University, Egypt.

Abstract:

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This paper discusses methods and techniques to be used for an ergonomic evaluation of products, product interfaces and systems. In this context evaluation is seen as a part of the design process that interacts with all design stages. It plays an integral role in it and is concerned with assuring a high degree of likelihood of the user's acceptance. Traditional and new evaluation methods such as task analysis, checklists, TA (talk/think aloud) protocols, CAD simulation are addressed.

Keywords:

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Prototype evaluation
Task-analysis

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1. Introduction

To succeed a product or system must provide satisfactory interaction with its user/customer on both a functional and a cultural level. Manufacturing companies are competing on national and international levels to achieve a competitive edge in the market. This creates demand for faster product development and production. Product quality refers to the performance, overall design and interface design of the product/system, the manufacturing process and the product life cycle. This means that better design developed in detail and based on applied research during the design and development process plays a significant role in the competitiveness of a company. This demonstrates the increasing importance of the role of design both for economic competitiveness and for improvement of the quality of life and work.
Design is a prediction concerned with how things ought to be. It is aimed at changing an existing situation into a preferred one. The designers attempt to predict the behavior of a product and its users using their knowledge and expertise. To use the product the human has to understand it. To achieve this designers have to understand what is the knowledge structure domain that humans have regarding products/systems and their contextual environment This means the environment in which products are used. However, designers still operate in their traditional role (that is professional-client relations). The designers receive the client's brief in which needs and wants are specified and design a product outside of its contextual environment by predicting the behavior of a product and its users on the basis of their knowledge as experts or from personal experience. The outcome of this are products/systems that do not respond to user's expectations. They are designed "for users" but not "with the users". The user is interpreted by a designer via market research information or designers utilize themselves as a user stereotype. This causes the problem of user interaction with products via their interface (Norman, 1986, 1988, 1993). However, the traditional role of the designer and client interaction is changing into a more complex one. This also means that in depth research is needed in order to design better and more valuable products/systems that will respond to contemporary demands. It will require designers to apply more sophisticated knowledge in order to respond to market demands and users' satisfaction.

2. Evaluation Methods and Design Process

The most innovative phase of the design process is its conceptual phase in which most decisions were made. With advanced product development and manufacturing more detailed product concepts are needed. This means that in this stage of the design process designers need to predict users' behavior and operation of products or systems. One of the major directions during the design process is *that the products should manifest end users point of view, from initial concept to their distribution to the market place***.** This means that user constrains should be included into the design project from its

initial stage and followed throughout the project consistently Popovic, 1983). In order to achieve this a designer must have the body of knowledge about users and their behavior which can be obtained from

(a) research,
(b) evaluation of same products/systems,
(c) evaluation of related products/systems,
(d) evaluation of predicted products/systems.

Therefore, evaluation is seen to be the part of the design process that interacts with all its stages. It occurs during the whole design process. Because of potential weaknesses in design concepts and their consequences evaluation should be reinforced. The nature of the design project determines which kind of methods, strategies and knowledge are required. Table 1 shows the most common evaluation methods/techniques used. They are applied for assessing product usability as separate techniques or in combination. The selection of the appropriate method will depend on design goals - which design constraints have to be evaluated. For example, to identify users' needs a designer may decide to select interviews or check list evaluation; to understand user's tasks and the knowledge behind them task and protocol analysis can be used. In this paper task and protocol analysis will be further due to their applicability to design and because they can complement each other.

Table 1. Common Evaluation Methods and Techniques *Protocol Analysis*

EVALUATION METHODS/TECHNIQUES	PURPOSE
CAD simulation models	To evaluate design and its perceived use during the different stages of design process.
Checklists	To define operations of a product/system and identify users' needs.
Interview users	To identify users' needs
Mock-up evaluation	To evaluate product usage with users participation
Motion studies	To evaluate motion performances and identify critical conditions
Protocol analysis	To evaluate a design, user's expertise level and understand users' concept of products.
Prototype evaluation	To verify a design outcome under real conditions.
Task-analysis	To define and evaluate operational procedures of a human/product/system.

The protocol method or the think-aloud (TA) method is applied to studying human behavior in different domains of expertise. This method was first described by Ericsson and Simon (1984 and 1993). It was expanded by van Someren et al (1994). The protocol method is widely accepted in the research community. Its data is unstructured and very rich and flexible analytical methods can be used. In general verbal and video recording of a user's task is taken. Transcripts are made, segmented, interpreted and analyzed. It is required that verbal protocol data should be put in an appropriate framework in order to get the best understanding of the analyzed activity. There is some criticism about giving verbalization concurrently with the cognitive processes (Baindrige, 1990). The distortion may occur if a person does the work in a non-verbal way and is not aware that other tasks as part of their skills is done automatically. It is possible that the verbal reports become distorted as task performance and verbal representation become incompatible. However, Berry and Broadbent (1984) investigated the relationship between cognitive task performance and reportable knowledge associated with it. Their experiments examined effects of task experience, concurrent verbalization and verbal instructions. They found that concurrent verbalisation did not have any effect on task performance. Despite of the criticism think-aloud protocol is found to be very useful for interface design, human computer interaction and human expertise. The method can help designers to get a better understanding of the principle behind their concepts. It is applicable at any stage of the design process.

What is product evaluation?

A product is a term for any item that has been manufactured and is useful to you. You are a consumer when you buy it or use it. Evaluation of the product means that its suitability and safety for use by consumers are checked out. All products made are required by law to be safe to use. This is not a requirement that they are absolutely safe - that is not possible. Nor must they be safe at unbearable costs to industry - that would put

innovation at risk. But they are required to be as safe as it is reasonable to expect.

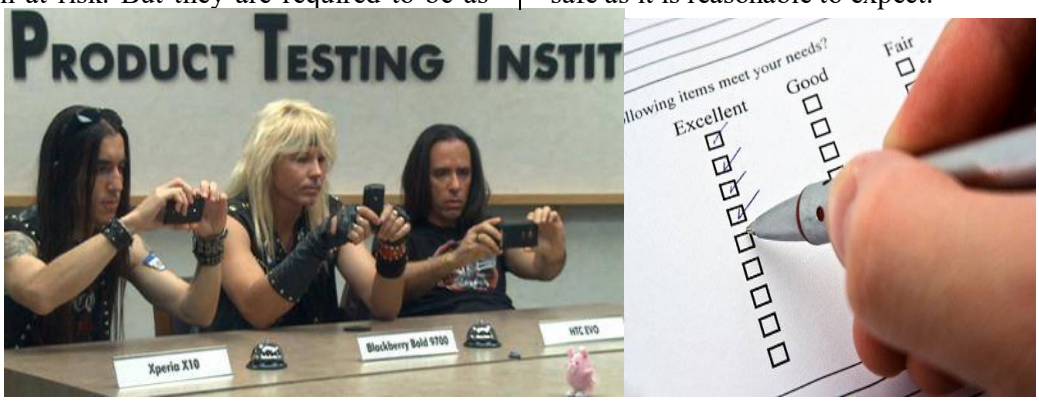

Figure (2-7) Product testing

This allows designers and manufacturers to be more creative in their product design, but it makes it more difficult for them to ensure that they have complied with the appropriate regulations. Even where there is specific legislation, manufacturers may not know if they have done enough to show due care, which is their main defense if a product supplied by them is subsequently judged to be unsafe. Evaluation will help.

Types of evaluation

Specialist laboratories can carry out testing of a product. They might do this for three main reasons:

- To prove that the product complies with relevant standards
- To investigate accidents to discover whether a product design fault caused the accident
- To compare a product with others of a similar design

Tests can include mechanical, physical, electrical, chemical and inflammability tests. These can evaluate product energy efficiency, reliability and durability, that is, the product should continue to work as intended over an appropriately long period of time. Finally, and most importantly, these tests can help to assess safety, but a fuller evaluation can be provided by using ergonomics because it looks at issues from the user's point of view.

Creating a safe product

Product safety is the main issue to consider when designing, evaluating or purchasing a product. A product may be unsafe for two reasons:

1. It might not have been produced as intended, because although the design was safe, there was a fault in the manufacture or inspection process — a manufacturing defect. For example, the locks on a folding chair may fail to engage properly, causing the chair to collapse when sat on.
2. The product might have been produced as intended and functions properly, but is still unsafe — a design defect. For example, a folding chair may unlock unexpectedly when the user tries to move it and traps their fingers. Design defects in products generally occur because the assumptions about the abilities and behavior of people using the products are wrong, or are not taken into account. If these defects are not put right, they may cause people to have an accident with the product. An ergonomist can provide manufacturers with the necessary information to minimize the risk of an accident happening .

Designers and manufacturers make products based on how they think people will use them. To create a product that is safe and easy to use, you need to find out information about the users and their behavior with the product. This information might be about:

- The product user
- The product environment
- The product itself

The product user

- Anthropometric data can make sure that the product is the right size for the intended user or range of users.
- If the product is intended for elderly people or children, it will need to be designed to deal with a limited range of reach or movement. Elderly people often have stiff joints that make it difficult for them to get up from seats which are too low, or to hold awkward objects properly.
- Gaps and clearances should suit the user. For example, bars on cots and playpens should be

close enough to each other so that a child cannot get their head caught between them.

- Designing a product using male body dimensions might mean that is it not suitable for use by females (and vice versa). Ideally a product should be suitable for use by small (5th percentile) women as well as by large (95th percentile) men (the smallest to the largest user).

Figure (2-8) a product should be designed for normal and abnormal use

- The product should not involve users in excessive physical effort, which might, for example, raise their heart rate, breathing rate, body temperature.
- Children are not good at understanding safety issues. They tend to be involved in many more than their share of accidents in the home, ranging from swallowing household chemicals and medicines (often pleasantly scented and colored, and not always in child-resistant containers) to scalding caused pulling on the lead of a boiling kettle. Suitable precautions for safer design are needed even if the product is not directly intended to be used by children.

The product environment

- The product should be evaluated under the same conditions as it will be used in. Some products, such as gardening tools are obviously intended for use out of doors and so must allow for users wearing gloves when it is cold, or for being used in the wet.
- Other products, such as bleach, may be used in a steamy atmosphere like a bathroom, and users may have trouble reading instructions and warnings if they are too small, as they may not be able to wear their glasses.

The product itself

- The product should be comfortable and easy to use. This can be checked during trials by asking users what they think about products through a structured experiment or questionnaire. Checklists can be used to ensure that all aspects of design and use are assessed.

Use and misuse

You may have created a safe product in 'normal' use but products are not always used as intended. There are likely to be unreasonable, careless and 'odd' consumers who use products for strange things! If you are making a product, you must try to imagine how it might be misused and design it so that it will still be safe. Obviously, this is not easy! To help with this, you can do a number of things.

1 **Review specific standards and general safety legislation that apply.** Details of standards can be found from the different standards bodies around the world, ISO, ANSI, DIN, BS or the Egyptian Standards EOS.

Figure (2-9) examine where the product is to be used.

Figure (2-10) examine ease of use and safety

2 **Look at accident statistics to see how relevant injuries are caused.** Detailed analysis of accidents can help identify patterns of behavior that, coupled with a particular product, lead to an accident. The chance of being involved in an accident depends on whether you realize that there is a hazard involved, whether you understand what it is, and whether you can do anything about avoiding it. Tables of accident data are collected by the Home and Leisure Accident Surveillance Systems (HASS and LASS) and are available from the Consumer Affairs Directorate of the DTI.

3 **Look at published data such as anthropometric tables,** to see if there might be a problem between a person and a product or environment. This can be particularly helpful when the user may be vulnerable, such as a child or an elderly or disabled person. If you know what size a user may be and what strength they may have to use the product, you can work out the consequences of them using it.

4 **Investigate complaints involving similar products.** People often report an incident with a product that was relatively insignificant, but it might otherwise have had serious consequences, and this can be useful information.

5 **Use ergonomists to evaluate a product and anticipate problems.** These 'expert appraisals' can be carried out using checklists

that ensure that all aspects of the product and its use are considered. These tests are useful for larger products such as kitchen appliances like cookers and fridges ('white goods'). Expert appraisals are particularly useful for carrying out investigations into products that have either been involved in accidents or where there are serious doubts about their safety. In these cases, the ergonomist can consider the abilities of a range of users. Expert appraisal can also be used before user trials to help work out the test method for the trials.

6 Carry out user trials with real, representative users. These are the most valuable source of information about a product's performance and can provide the best quality of data to make a decision to change a design or make a new product. They typically involve watching people carry out a careful set of activities using the product. A special type of trial is a home placement of products where a product is given to someone to use in a real setting for longer periods of time. In these cases users might have the product for 1 or 2 weeks so that a whole cycle of use can be studied. They might be asked to keep a diary of use during the time and report on any problems, or be given a series of tasks to do and report on. They will then be observed using the product at the end of the period, when they will be more familiar with its use. This can be more realistic than a laboratory based trial. Examples of products that might be tested by a home user trial are domestic appliances like kettles and vacuum cleaners, which are familiar to most people, and do not need to be installed.

Supervised user trials may be used where there are known safety issues, such as with garden compost shredders or lawnmowers. These trials are also good for giving people more tasks in a given time than they would normally get at home.

When you have all this information about a product, you can then carry out technical tests to see what will happen when your product is misused in the ways that you have identified. These will provide the answers to the 'What if?' questions. Technical tests can be used to simulate a real user. If used with data on strength and size, it is possible to test products in a similar way to how they will normally be used. In many cases this is the basis for Standards, with an additional allowance being made for a margin of safety. In the case of dangerous products, or those that have already caused an injury, it is clear that the only safe way to test is to do it with technical tests rather than endanger users in trials.

HAZARD v RISK

A hazard is a potential source of harm that could result in physical injury and/or damage to health or property. For example, a trailing cable might be a trip hazard - it might cause you to trip and injure yourself.

A risk is the probability that an injury will occur. If you are not looking where you are going and you walk towards a trailing cable, the risk is quite high that you will trip over it and injure yourself.

Instructions and warnings

It is very important to evaluate the instructions and warnings that accompany products. The content and appearance of instruction manuals and warnings is very important if they are to be understood properly. In the workplace, instructions and warnings reinforce what has already been learned through education, training and supervision. Obviously, at home, this is not available and users must rely solely on printed instruction manuals and warning labels. These often fail because they do not provide the right amount or type of understandable information.

Figure (2-11) Evaluate instructions and warnings that accompany products

You do not need to tell the user about obvious hazards, for example, that knives are sharp. But you must warn users of the non-obvious hazards of your product, both for its intended use and its

foreseeable misuse.
There are three types of warnings that you can use:

- Labels printed on the product,
- Separate text in the instruction manual,
- Highlighted messages throughout the instruction manual.

The main purpose of all warnings is to get users to behave more safely with products. To be effective, a warning must:

- Be seen - it must catch the user's attention by its design and presentation.
- Tell the user about the hazard and how serious it is.
- Tell the user about the consequences of failing to follow the instructions or of misusing the product.
- Include further references to other sources of information about hazards.

Warnings are not an excuse for bad design. Warnings will not prevent a product being considered defective by law if the hazard could have been removed through proper evaluation and design in the first place.

Task Analysis

Task analysis is used to evaluate products and the user's interactions with them via their interface and assess their usability. In this context task analysis refers to overall user's activity. Its most common form of representation are diagrams or charts. The methods and techniques are different for specific applications such as workplace design, medical equipment design, interface design, or knowledge elicitation. Many task analysis of different products I conducted identified the discrepancy between users' and designers concepts of product or systems. The outcome of this analysis is used as constraints for new product designs and their concept evaluation.
Task analysis and protocol method compliment each other. They can be used concurrently. In case when distortion of a TA protocol may occur task analysis can clarify the sequences of operation. Video recording of the performance during concurrent verbalization can be analyzed to determine task components. In this situation task analysis techniques are used to support protocol data.

3. Conclusion

End user satisfaction is becoming more and more a standard requirement for all products and systems we design and use. Kato(1986) referred to Moran's paper in which he pointed out that it is unsuitable that designers use themselves as users as they differ from them. This approach is still common in many other design areas where designers design a product based on personal experience. This is not acceptable because designers' concepts and users' expectations and understanding of the system differ. This suggests that users' knowledge is different from the designers' knowledge. (Jørgensen, 1990). Therefore, it is very important that designers must understand that they need to take into consideration many different factors and study, users' needs, expectations, concepts, behavioural patterns, culture and the contextual environment in which the products are used in order to assure user's acceptance.

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