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Analysis of ergonomics conditions of a brand of mattress and pillows. University-Industry project, Medellín - Colombia

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Abstract. This project presents an analysis of the ergonomic conditions of three types of mattress and three types of pillow. The products are manufactured by a Colombian company which specializes in flexible polyurethane foam and other products designed for rest and relaxation. The project was developed through the University – Industry relationship: a strategic partnership based on the knowledge and strengths of each component. The conceptual theories that underpin the Ergonomics Research Division of the Design Studies Research Group (GED) provided the methodological approach for the project: the characteristics, the requirements and the relationships that are established between the components that constitute the User – Product – Context system (basic principles of the Ergonomics – Design relationship). An important factor in the project was the conception and measurement of comfort. Comfort can be measured on an objective level (quantitative measurement), and on a subjective level (a user's particular perceptions and tastes). What constitutes 'comfort' can vary from person to person, thus making the identification of criteria for the standardization of consumer products problematic. This project enabled design recommendations to be made to the Company vis-à-vis future proposals for mattress and pillow products. This experience of applied research was carried out by professors and students from the Faculty of Industrial Design at the UPB in Medellín, Colombia.

Keywords: product evaluation, comfort, design requirements

1. Introduction

As a result of the interest shown by a manufacturing company which makes flexible polyurethane foam and other products designed for rest and relaxation, the Ergonomics Division of the Design Studies Research Group at the UPB embarked on a project based on the University – Industry relationship. This model constitutes a strategic partnership based on the knowledge and strengths of two components: the manufacture of materials and supplies, and the design and the marketing by the Company, and the generation and transfer of knowledge by the University.

The objectives of this project centered on the evaluation of three types of mattress and three types of pillow. The project assessed if the Company's products fulfilled ergonomic conditions (in a commercial context, a feature that is deemed valuable for users).

The following factors were considered relevant in the project: the definition of criteria that should be analyzed according to the vision of Ergonomics and Design (what is ergonomic); and the conception and measurement of comfort on an objective level (the

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quantitative measurement) and on a subjective level (a user's particular perceptions and tastes). What constitutes 'comfort' can vary from person to person thus making the identification of criteria for the standardization of consumer products problematic. [2, 3, 13, 14]

In addition to the conclusions drawn from the evaluation of the selected products, the project identified design requirements for the development of the Company's future mattress and pillow products.

2. Methodology

According to the Ergonomics Division of the Design Studies Group at UPB, several thematic units, subjects, elements and components should be considered throughout a product's Design process. They are based on the User-Product-Context system and develop moments/activities which allow Designers to use the process in a way that is systematic and coherent to the perspectives and approach of Ergonomics[11].

The project was developed in three stages, as shown in Figure1. Outline of Project Methodology.

2.1. Stage 1. Identification

In the first stage, certain thematic units (project variables) were identified which systematically guided and organized information derived from the project. This was achieved through the application of the vision of ergonomics and design i.e. from the characterization and understanding of the components of the User – Product – Context system. See Figure1. Outline of project methodology.

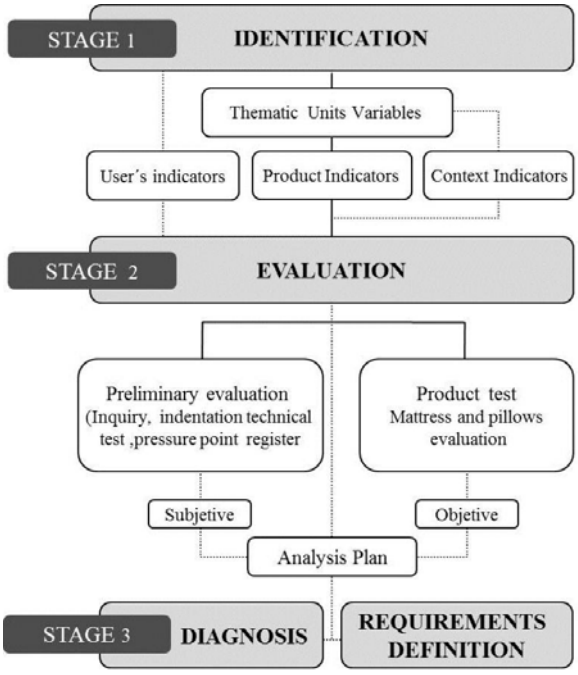

Figure 1
Outline of Project Methodology

From each of these components, a series of indicators were established based on physical, cognitive and organizational dimensions, as per the International Ergonomics Association's (IEA) [8] definition of ergonomics, and other criteria discernible in methods and techniques of design e.g. a list of attributes, industrial products' Values of Use [5], etc.

The objective of these indicators was to establish a theoretical framework for the project, define the criteria for evaluating the products and develop and analyze the user evaluation tests.

The project's reference points were: mattresses, pillows, sleep and relaxation.

The following indicators were considered for each of the thematic units: User – Product – Context:

User Indicators:

- Psycho-physical features: gender, age, body type, postural characteristics, anthropometric characteristics, physiological and pathological concerns relating to sleep, significance of sleep and relaxation to the user, educational level, occupation, socio-economic position, etc.
- Relaxation and sleep patterns.
- Patterns related to the elements used for sleeping and the context of their use as defined by the project, viz. the bedroom.
- Knowledge, perception and appreciation of the Romance Relax brand, and other similar brands.

Product Indicators:
- The characteristics of the bed and the mattress; product antecedents.
- Components and physical attributes (materials and supplies).
- The life cycle of mattresses and pillows.
- Durability. Maintenance and associated risk factors.
- Legislation and standards in the area of mattresses and pillows.
- Entities related to the national and international context.

Context Indicators
- Environmental features.
- Temperature, dust, humidity, mites.
- Socio-cultural features relating to the use of mattresses and pillows.
- Domestic context.

The aim of the first stage was to achieve a greater understanding of the themes associated with mattresses and pillows, and the themes associated with ergonomics and design. This would allow the theoretical criteria for analyzing and describing the ergonomic conditions of mattresses and pillows to be deduced. In addition, an understanding of context was achieved vis-à-vis rest patterns in the home. The Company was approached with the aim of increasing brand familiarization, identifying product characteristics which would help in evaluating ergonomic conditions, and identifying design opportunities for the Company.

The design opportunities refer to future products that can be developed by the Company after an understanding of context had been achieved through observation of new rest patterns and behaviour. This theme was developed by the Material Cultural Division of the Design Studies Research Group [12].

This stage was conducted as an educational research exercise, employing students in the 9th semester at the Faculty of Industrial Design as research assistants.

2.2. Stage II. Evaluation

In the second stage of the methodology, characteristics and details related to each of the indicators were established, important features and opportunities were analyzed, and product design components were considered, based on the Disciplinary Model and the Educational Project – part of the Curriculum at the Faculty of Industrial Design at the UPB [4].

These included:
- The functional-operative features i.e. technical features relating to shape and material, the product's utility (what it is used for), and the Human-Object relationship i.e. the criteria that facilitate the product's adaptability to the users, taking into account their characteristics, capacities and limitations.
- The aesthetic-communicative features which include, among others, symbolic features: what the product expresses according to its appearance and aesthetics, and the signification it provokes in the different users.
- Technical-productive features i.e. those related to material, technological and productive dimensions of the product, and the nature of the manufacturing process.

This stage comprised the moment for evaluation, analysis and contact between human and object in the designated context, and to determine the way that the relationship of use is established.

2.2.1. Preliminary test

Preliminary evaluation tests were carried out which helped define the instruments required to measure user value. See Figure 1. Outline of Project Methodology. These tests included:

An initial pilot test in the form of a preliminary survey, carried out in the Company's showroom. The purpose of these tests was to visualize the features that should be taken into account in the development of definitive tests.

In this experimental phase, student research assistants developed technical indentation tests which sought to identify the behaviour of the material when pressure was applied by the weight of each area of the body. Anticipating the importance of measuring pressure points when the user is in contact with the mattress (as indicators of conditions of comfort), an experiment was conducted that looked at alternatives given that an instrument required for carrying out such tests was not at hand at this time.

Sales staff in Bogotá, Medellín and Barranquilla took part in workshops to identify the use and appropriation of the terminology related to both product attributes and the ergonomic criteria that was considered in the research phase.

2.2.2. Comfort evaluation test

A survey and evaluation tests of the mattresses and pillows were then conducted using 149 users between the ages of 16 and 45 or above, and from different

socio-economic backgrounds, with the aim of identifying their relaxation and sleep patterns, and their perception and acceptance of the Brand. Similarly, the use and appropriation of the terminology utilized by the users to describe product quality was analyzed, as well their understanding of the terminology related to the project's general objective.

This information was compiled in accordance with the variables and indicators identified in Stage 1.

The following was considered in the evaluation of the mattresses:

- An objective measurement (quantitative) of comfort levels, in which an X-Sensor Rug was acquired by the Company for the purpose of the tests. In addition to measuring the pressure points and support area when the recumbent user makes contact with the mattress, the rug also helped determine which of the tested surfaces provided the highest levels of comfort for each user.
- A subjective measurement, in order to identify comfort value for each of the subjects. Using a scale of 1 to 10, subjects were asked to evaluate levels of comfort and firmness of each mattress.

Each subject carried out both subjective and objective tests using three surface conditions:

- Condition 1: A mattress supplied by the Company (three types were tested: firm, semi-firm and extra firm).
- Condition 2: A mattress supplied by a competitor (two different brands of mattress were used).
- Condition of control: A table that acted as a control surface (this table had the appearance of a mattress, and was covered by the same material that was used to cover the other mattresses).

During the test period, the mattresses from the Project and the competitor were randomly changed every two days to guarantee the arbitrariness of the test. In other words, each subject had the same probability of using any of the mattresses in each of the two experimental conditions.

In order to guarantee identical conditions of temperature, humidity and cleanliness for the subjective evaluation tests of the mattresses from both the Project and the competitor, a spacious and airy room was used for the three experimental conditions.

The results of the tests were compared.

A subjective evaluation (qualitative) was carried out with the pillows. At the same time that a survey was conducted that assessed sleep and relaxation habits, each person was asked to use the Project's pillows for a certain period of time, after which they were questioned about their perceptions relating to comfort and firmness using a numerical scale similar to that used in the evaluation of the mattresses.

A theoretical approach based on the perception and assessment of comfort formed the basis of the evaluation tests. [6, 7, 9, 10,13, 14]

2.2.3. Analysis plan of the comfort evaluation tests

In order to identify relationships of interest, the information analysis plan entailed three moments and activities: a descriptive analysis of the information obtained through the survey, in order to identify how the sample product behaved vis-à-vis each of the three variables – user, context and product; analysis of the comfort evaluation information obtained from the X-Sensor Rug objective test; and the subjective test which looked at user perception:

Descriptive analysis: once the information had been organized, the behaviour of each of the variables was described and classified:

- Sample characterization based on the 149 surveyed users.
- Characterization of the behaviour of the variables – user, product and context, in relation to the mattresses.
- Characterization of the behaviour of the variables – user, product and context, in relation to the pillows.

Relational analysis: results were classified in double-entry tables which permitted an analysis of the relationships of interest between the different variables.

Evaluation of Comfort: in order to complete the analysis of the evaluation of comfort, descriptive quantitative analysis was applied using simple frequency tables, and relational analysis was applied in order to compare average valuations of comfort. The latter was applied using the Student's t-test, a statistics method used to ascertain the differences between sets of data.

Registration documents with descriptive analysis, cross-variable documents with corresponding conclusions, and analysis matrixes of the products provided support for the analysis plan.

2.3 Stage III. Diagnostics and definition of requirements

In addition to the results obtained in the comfort evaluation tests, seen as indicators of perception and acceptance of the Brand, Stage III entailed an observation and verification exercise which looked at how

the Company relates information to its potential customers through publicity material, salesroom publicity and advertising on their website. This exercise examined how criteria such as product material, product finishing and attributes relating to user welfare were communicated to customers. These criteria, seen as Brand values, included the product's ergonomic conditions.

The objective of this analysis was to verify the consistency between the characteristics that the brand offers and the product's actual attributes. This analysis was conducted by means of a characterization and criteria interpretation matrix. Each product is presented in a clear and detailed manner, showing the properties the product possesses the product's function and how it benefits the user and/or its target market.

The diagnostics and design requirements for the development of future proposals were formulated based on the theoretical and conceptual outcome of the project (see 3.2), as well as the information obtained from the evaluation of the Company's products. The requirements were presented as a list of recommendations which focused on the ergonomic conditions of the Company's products.

3. Results

The project yielded results that constituted a benefit for both parts of the University-Industry model. For the Company, information obtained will allow it to:

- Assess the development of processes related to information and product sales. This includes sales tactics associated with the themes of Ergonomics, Design, Comfort, etc.
- Carry out adjustments, and consider the development of future products.

For the University, the generation and transfer of knowledge i.e. the possibility of research in specific areas, and the establishment of new approaches, relationships, procedures, etc., in the area of Ergonomics and Design.

3.1. Products

- Stage I (Identification): outline of the Project's variables and indicators, the theoretical framework and a glossary of the terminology of mattresses, pillows, comfort and relaxation, definition of design opportunities and an analysis of the Brand (criteria that the Company can take into account when defining new strategies to consolidate their market position).
- Stage II (Evaluation): the formulation of a methodology for evaluating the product. In the preliminary tests, the results of the pilot testing: the preliminary survey and two experiments based on the behaviour of the material in relation to body weight and the recording of pressure points when the mattress is used.
- Furthermore, the results from the workshops conducted with the Company's sales team were a guide to the way in which the Brand's future products are offered to customers.
- The following results were achieved through the Evaluation Tests with the users: a chart of data collection, record charts of each user's pressure points when in contact with the sample product and corresponding data in the X3-Comfort Index 6 software format.
- In Stage III (diagnostics and definition of design recommendations): recording of information vis-à-vis specific criteria that the Company can use for future development.

3.2. Concepts

- The concept of Ergonomics can be regarded as an attribute or value for a particular product, in relation to characteristics of shape and material. Ergonomics is often linked with the concept of Comfort; both are associated with sensations of pleasure and conditions of well-being for the user.
- It should be understood that Ergonomics seeks to optimize the User - Product - Context relationship. This relationship exists through the use of the product and must express (or take into account) features of these three elements for the well-being, health and security of the users. A product will achieve higher levels of acceptance by considering the features of each of the components of the User - Product - Context system.
- With the above in mind, the shape and material alone does not mean a product is ergonomic. Human variability should be taken into account, not only with regards to physical features (age, gender, physique, distinctive characteristics, health issues, etc.), but also features relating to tastes and interests, as well as the conditions of context in which the product is used (cultural

considerations and/or environmental conditions: light, temperature, noise, etc.).

- A product needs to be utilized in order to determine a degree or level of acceptance. In other words, product utilization will allow people to define which characteristic(s) best fulfil(s) their requirements/needs.
- A product can fulfil ergonomic conditions for a particular group of users, but there is no guarantee that it will be a value for all users.
- Comfort is a subjunctive concept, peculiar to each person according to their characteristics, experiences and personal tastes. Therefore a product can be deemed comfortable by some people, but not by an entire group of people.
- It is not possible to identify the exact causes of comfort or discomfort; however it is possible to identify key factors that can be considered in the process of design, thus generating certain conditions of comfort.
- The concept of comfort cannot be standardized. It does, however, include some factors that can be common for a particular group of people: the attribute of firmness can be comfortable for some users, others prefer a softer density.
- It is feasible to objectively (quantitatively) evaluate indicators in the use of mattresses: pressure points and areas of support for example. However, it may not be consistent with the perception of the individual (subjective evaluation).
- In a commercial sense, diverse brand products can include certain values for the users e.g. anti-allergen, antibacterial, lightweight, etc. However, values relating to ergonomics, orthopaedics and comfort are not supported by any study.
- Products are purchased with the values of ergonomics, orthopaedics and comfort in mind; however no clear criteria or follow-up exists once a product has been purchased. For example, a study that defines if the perception of the Brand (the image and what the products express) and its use (how people feel when using the products) are consistent with, and loyal to, the arguments put forward by the Brand.
- Brand image influences the perception of a brand as well as purchasing decisions. Brand image should reflect actual product values, providing that what is communicated is articulate and coherent.
- The theory of ergonomics has been particularly used in the promotion of 'high-end' catalogue products, thus justifying a higher economic value. Ergonomic conditions must be expressed as a brand value and not articulated as a factor of price.

4. Conclusions

Based on this experience of applied research for industry, the following conclusions can be drawn:

The methodological proposal put forward by the Ergonomics Research Division at UPB, which classifies information from the project based on the components of the User – Product – Context ergonomic system, organizes and conducts the search for information based on project and Company needs. Certain indicators are then generated for a particular usage situation, in this case mattresses and pillows.

The evaluation tests were designed with the specific needs of the Company in mind, and constituted a tool which was used to assess the way in which the Brand incorporates ergonomic conditions in its products i.e. the characteristics and requirements of the users, and the way in which a product's features are determined. It includes criteria of use for the mattresses and pillows, and seeks to optimize the User – Product – Context relationship for well-being, health and security.

It would be beneficial for the University – Industry relationship (Grupo Espumados and the UPB) to encourage research into the concept of comfort. Although essentially a subjective concept, comfort can be measured through tests with users to determine specific factors that influence their perceptions, the findings of which can be implemented in the design of the Company's products.

In depth analysis of information is required in order to identify future design requirements that are coherent with the values of the users.

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