THE SIMULATION OF CORPORAL EXPERIENCES AS A STRATEGY FOR THE ELDERLY INCLUSION IN THE DESIGN PROCESS

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Abstract: Although there are several implementations and ways of carrying out a simulation, this text will emphasize on the usage of this tool within the product design and development environment. While this topic is generally performed in the testing phases, it's important to encourage simulations in order to fully assimilate design issues and the features of the User – Object – Context system since the early stages of development. All this process is done to avoid errors in the way a designer interprets the information found in literature as inputs or design guideline [5, 9, 13, 14, 15, 23]. Based on this approach, the Ergonomics Research Line of the Industrial Design Faculty of the Universidad Pontificia Bolivariana, propose the development of the research Project, whose general objective is to develop a system of elements that allow the designer to simulate functional states of users with particular physical characteristics. In this case the user of the elderly was approached as the theme of the project.

Keywords: Pedagogical-tools, Simulation, Product-design, Elderly, Product design-specification, Simulation suit-Industrial design.

Introduction

Information and Communications Technology (ICT) has had its biggest impact in the field of science education, helping students at different stages in their schooling and improving the performance of teaching staff [19]. Included in these educational technologies and methodologies are simulation techniques, which are used to improve the performance of a particular system and broaden its application to cover different pedagogical disciplines and approaches.

Simulation techniques allow students to inhabit a context that replicates some aspect of reality, and establishes within this context certain situations, activities and/or problems that correspond to real life. The use of simulation enhances and accelerates the quality of the student learning process, systematically integrating itself into the pedagogical model [16].

Simulations can be used and applied in a variety of ways, including sensory information gathering, context-based laboratory work and training in different disciplines such as engineering, medicine and construction [19]. This paper, however, will focus on the use of simulation in product design and development.

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Moreover, although this technique is commonly used during the testing phase of a project (once a prototype or at least a tangible product idea has been developed), it is important to use simulation in subsequent phases to improve understanding of those variables inherent in the design process, such as human factors and the relationship with the object and the context of use. This will enable students to accurately define the possible requirements of the user.

Simulation as a concept in the learning process

According to the Real Academia Española (Royal Spanish Academy), to simulate means to "represent something, by pretending or imitating what is not". However, from a pedagogical perspective, a better definition of simulation is provided by Cristina Davini and Litwin, who understand it as "a teaching method aimed at familiarizing students with situations and features similar to those found in reality, but which actually exist artificially. The objective is to train students in the practical and operational skills that they require to adapt those situations and elements to the real world [6, 10].

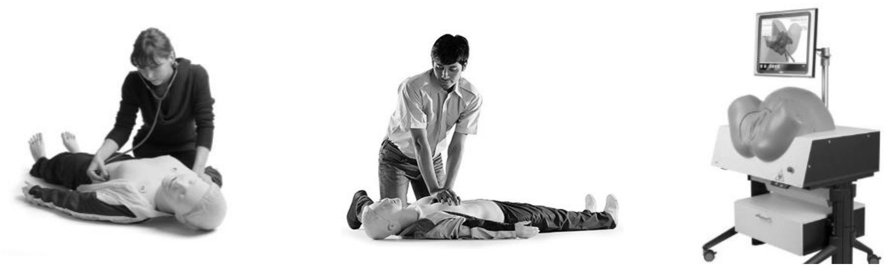
Simulation can recreate situations and establish experiments thanks to the visualization of a physical system and the link between reality and abstraction. This helps create a dynamic and interactive learning environment during the entire student learning process. Simulation also helps explain and illuminate a particular topic by acting as a support mechanism and collaborative learning tool to establish necessary conceptual foundations, or to reinforce what has been learnt in the classroom [12]. This motivates the student and encourages greater participation; at the same time skills are developed to visualize the consequences of certain decisions, and to practically apply theoretical knowledge [8].

As part of the learning process, simulation can be used at two key moments: during the teaching-learning process, and at the evaluation phase. In addition to providing techniques for diagnosing, treating and solving problems, simulation can help improve psychomotor and relationship skills more efficiently than other methods by focusing the student's attention on a clear objective, and then reproducing it as part of a standardized process. In the evaluation phase, simulation helps measure data search capability and interpretation, and assess the types of problems raised during the activity [4].

Applications and approaches of simulation as a pedagogical strategy

Different types of simulation techniques exist, and will vary according to their application, resources, objectives and required expertise. The following types can be high-lighted: (i) three-dimensional simulators, such as cardiorespiratory, multipurpose, obstetric, etc., which emit signals from a system that allow medical students to diagnose a particular scenario; (ii) visual and/or auditory stimuli, used in any given discipline or stage of education, and which focus on the human senses to obtain information; (iii) computer-aided simulation, used in disciplines such as design, medicine, engineering and construction to generate 3D models based on an initial idea; (iv) the simulation of a theory using case studies, applying concepts to a real-life situation [4, 18].

The concept of simulation as a pedagogic strategy has been used a lot more in the area of healthcare, specifically to: (i) define a student's level of clinical competence; (ii) assess the effectiveness of a study plan according to a particular objective; (iii) under-stand beneficial habits and skills that can be used with healthy and sick individuals, reducing pain and discomfort, especially when dealing with large groups; (iv) carry out practices similar to reallife interaction in a particular occupational area; (v) examine reproductive techniques, algorithms and problems to help foster habits and skills; (vi) perform scientifically applied maneuvers and procedures, both under supervision and independently; (vii) link the understanding of clinical, diagnostic and therapeutic techniques and procedures with real life situations, as well as complementing them with other teaching methods [1, 17]. The area of healthcare has been fundamental in the development and evolution of simulators; the first simulator devices were used in anesthesiology, such as the Resusci Anne manikin (Fig. 1a), designed by Asmund Laerdal (Fig. 1b) and Sim One (Fig. 1c) designed by Abrahamson and Denson [11, 20].



a) b) c)

Fig. 1. Examples of simulators used in medicine a) Resusci Anne, b) Asmund Laerdal, c) Sim One
Source: [11, 20].

Simulation as a tool in product design

The conceptualization and testing phases of product design and development employ a number of different simulation tools and techniques, such as constructive interaction, mock-up, role play, resource flux, user proof, OCRA, RULA, walkthrough analysis and others. These tools and techniques should also be implemented in earlier phases that seek to gather and analyze information relating to the user-object-context system. Typically, these phases are the most demanding for a designer in obtaining explicit, observable, tacit, and latent knowledge of the user. These phases also pro-vide opportunities for feedback based on user perception [5, 9, 13, 14, 15, 23].

Based on this idea, the Ergonomics Research Division at the Pontificia Bolivariana University's (UPB) Faculty of Design suggested setting up a seedbed research group to develop a research project whose general objective was to create a system that allowed a designer to simulate the individual functional states of a particular user. This would allow designers to better understand the user's listening, visual and motor characteristics, postural condition, and relationship with an environment conceived for the information gathering stage of the design process.

What strategies in the teaching-learning process could help students better understand the physical and cognitive characteristics of the user? Based on detailed analysis of design teaching methods and other fields, it was shown that "simulating" human activity was imperative. For the purposes of the project, "simulation" was defined as: "The process of designing a model of a real system and conducting experiments with this model to understand the behavior of the system" [22].

Project: "Bodies simulating the functional state of elderly adults"

Because of the growing number of elderly people in Colombia, it was decided that the user in this particular project would be an older adult. Indeed, by 2050, the number of people aged 60 years or over is expected to reach 15 million people, or about 24% of the total population [3, 21].

Moreover, there is evidence to suggest that mass-produced, everyday products and contemporary urban arquitectual spaces have been poorly adapted to meet the needs of people between the ages of 65 and 90. From a usability perspective, activities become inefficient, limited and prone to accidents that can be harmful to the user [3].

Designers have paid too little attention to this particular niche in the market, detaching themselves from a problem that is affecting communities both nationwide (where a "rise in the elderly population in Colombia is beginning to outpace the growth of younger generations," [7]) and at international level. Problems persist because products are designed under optimum conditions of use and earmarked for users without severe physical limitations, creating commercial rather than social designs.

Methodology

The following methodological process was used for the ERGO seedbed research process.

Selection of clinical conditions

As part of the research process, this stage consists of a series of activities using bibliographical references and expert opinion to examine how an elderly person is affected by conditions related to the aging process. Following a review of the information, medical conditions that could be simulated for each of the projects are selected.

State of the art knowledge

Alongside this enquiry process to select the medical conditions to be simulated for each of the projects, a "state of the art" study was carried out that identified a wide range of objects linked to the treatment and control of medical conditions. The study, which also identified objects used to simulate the functional state of an elderly per-son, aimed to gather relevant information that responded to the demands of each product.

Design Process

Following the research phase and the analysis of the problems faced by elderly people linked to postural and movement degeneration and the loss of hearing, sight and fine and gross motor skills, a series of design approaches were examined that responded to the objectives of each project.

Following on from this stage, relevant data from the project was brought together to determine the requirements of the functional-operative, techno-productive and esthetic-communicative components. During the design process, and based on the requirements of simulation, the different types of components, mechanisms, shapes and materials were established that would reproduce the selected medical conditions. This aimed to kick start the formal research process to establish early designs and models that would enable the development of a first validation and, subsequently, a second improved prototype.

Results of the project

Visual-Hearing Simulator

The objective was to develop an element that represented the different visual and hearing limitations linked to the ageing process. The research recognized four main age-related conditions that were earmarked for simulation: (i) cataracts, (ii) glaucoma, (iii) macular degeneration, and (iv) diabetic retinopathy. The following hearing disorders were also deemed to be prevalent among the elderly: (i) presbycusis, and (ii) tinnitus.

The simulator comprises a structure that supports a series of transparent screens. Polarizing film or laminate has been attached to the screens and digitally altered according to the characteristics defined by visual impairment at different stages of development. The simulator has an adjustable strap system to ensure a more comfortable fit, while the screens are prevented from coming in to direct contact with the face to ensure the structure remains hygienic (Fig. 2 and 3).

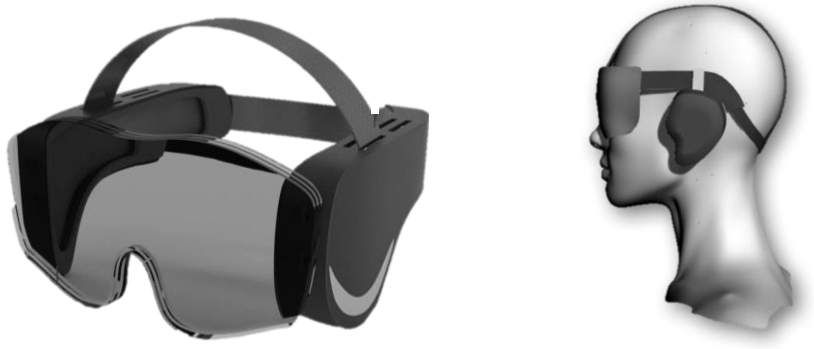


Fig. 2. Visual-hearing simulator concept
Source: student presentation – seedbed ERGO – UPB.

The hearing simulator is attached to the simulator structure to form a single system. The design comprises anatomical earmuffs and polymer material that can be adapted to fit the shape of the user's head and face. Three types of foam of varying density reduce high-pitched sounds (presbycusis) to generate three levels of external noise insulation. The simulation of tinnitus is conducted through earphones incorporated in to the interior part of the simulator. A Bluetooth connection links a sounds folder, which can be downloaded or reproduced using a website or mobile application (Fig. 3).

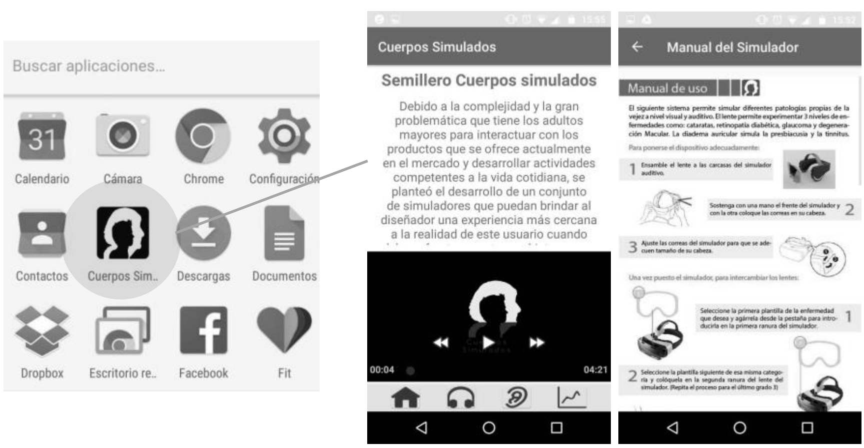


Fig. 3. Hearing application
Source: student presentation – seedbed ERGO – UPB.

Simulator of fine motor skills

The objective was to develop a glove that simulates fine motor skill limitations in the hand as a result of the ageing process. The simulated condition is rheumatoid arthritis, characterized by joint inflammation.

The glove was created using the elastic properties and vectorial force of the textile to generate a counterforce to hand movement. This enables applied exertion and movement precision to be reduced, simulating the loss of muscle mass. Reinforcement materials located in the phalangeal joints allow the glove to generate a compression force. This limit the range of flexion-extension movement during different grip positions of the hand, simulating the discomfort of arthritis (Fig. 4).

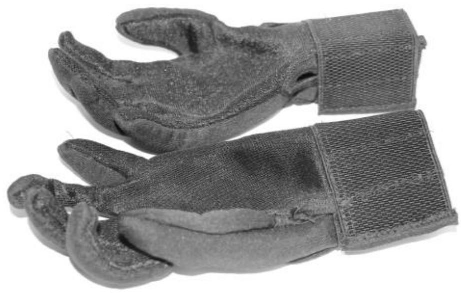


Fig. 4. Fine motor skills simulator concept
Source: student presentation – seedbed ERGO – UPB.

Posture-movement simulator

The objective was to develop a harness to recreate the posture and movement of an elderly person. The aim was to reveal the following features of biomechanical and postural change linked to the ageing process: (i) the increase in the curvature of the upper back (kyphosis), (ii) the lateral curvature (left or right) of the spine (scoliosis), and (iii) the exaggerated curvature of the lumbar zone (lordosis) [2].

The harness system employs an adjustable strap mechanism that tilts the back for-wards at different degrees depending on the level of curvature required, thus enabling the user to adopt the required posture. Tension control of the strap mechanism also allows the user's body to tilt sideways, enabling a sideways movement of the back. The posture system's strap mechanism is connected to the movement simulator, which in turn is fitted to the user's knee. Flexion-extension movement is restricted in a controlled manner through tensors (thera tubes) that possess varying degrees of elasticity. The two systems are brought together to reduce stride length and walking speed thus effectively recreating the biomechanics of an elderly person (Fig. 5).

Fig. 5. Posture and movement simulator concept
Source: student presentation – seedbed ERGO – UPB.

Conclusions

The use of "simulation" as a pedagogic strategy in the process of design allows the designer or student to: (i) demonstrate what has been learnt in the research and problem definition stages, translated into design inputs, thus reacting in advance of what may happen in a real context, (ii) obtain accurate data during the exercise, (iii) define the User-Context-Object system under analysis, based on the designer's experience and perception of the situation that simulates reality, (iv) develop clearer understanding of the activity's objectives, (v) replicate the experience, (vi) standardize the process, (vii) implement the teaching exercises, (viii) evaluate criteria related to reality, (ix) establish evaluation criteria, (x) develop a wider range that is more representative of the problems, according to the particular design case, (xi) ascertain student performance.

Despite this, it is important to clarify that simulation is still only a technique that simulates reality. An exact reproduction of people's lives and behavior is difficult, and represents the concept's biggest limitation. Caution is therefore advised when predicting a situation based on the findings of simulation. It is important to recognize that an individual may react differently to a real-life situation; therefore simulation alone is insufficient when attempting to understand a real context or user. Subsequent tests must be carried out to determine if the information gathered during the simulation phase is accurate, and if the exercise can be repeated for different individuals with the same profile.

The scope of the project is earmarked for academic use and implemented in UPB's ergonomics laboratory, which is always striving towards improving the learning process of Industrial Design students. In addition to the prototypes, a guide and user manual has been developed for elderly people to complement the usability of the design objects.

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