Ergoshow: a User Centred Design Game to Make Children Aware of Ergonomics and Occupational Safety and Health

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Ergoshow: a User Centred Design Game to Make Children Aware of Ergonomics and Occupational Safety and Health

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Abstract.
Multimedia has become part of youngsters’ daily life, although the quality of the current products is not always satisfactory from an education point of view. Sadly, many multimedia resources are not used as tools for socializing, transmitting knowledge and knowhow for improving society. Thus, the aim of the research was highlighting the importance of the User-Centered Design (UCD) for developing an educational information system, based on a computer game, for improving knowledge in the Ergonomics and Occupational Safety and Health for children domain.

Keywords: Multimedia Games, User Centered Design, Usability, Occupational Safety and Health

1. Introduction
Nowadays, teachers often mention that students were not motivated in the classroom and that this could reflect on their learning outcomes.

This problem normally occurs in the traditional learning process based on lectures that usually is not very stimulating for young people. An explanation for this might be the fact that children are now familiar with multimedia systems, which are more interactive and exciting. A longitudinal study of 140 low-income children and their use of Internet at home, developed by Michigan State University, reported that game
play is their primary reason for using computers (Jackson et al., 2005). Gentile and Walsh, 2002 showed that American children aged 2-7 play computer games an average of 43 min/day, children aged 8-12 an average of 56 min/day, and teenagers aged 13-17 an average of 78 min/day. The game industry is conscientious of this data, according to “The New York Times” of 2003/10/23 and the investments volume proposed for 2002 for designing multimedia systems in the whole world, either for diversion or training exceeded the investments intended for research in the pharmaceutical industry.

So one way of keeping the modern student active is to explore the use of information technologies (Muir-Herzig, 2003; Dwyer, Ringsta and Sandholtz, 1991 and Negroponte, Resnick and Cassell, 1997). However, these authors highlight the important role that teachers should have, as it is necessary and essential that they change their forms of teaching. In this context, the new paradigm is that teachers no longer are the sole holders of knowledge and the only means of transmitting it in a valid and acceptable way. The student becomes the central character in the classroom and the teacher must prioritize the content, make a note of the difficulties and needs that their students have Skolov (1999).

The research conducted by Knezek, (1997) and McFarlane et. al. (2002) shows that the use of technological information resources for education of children in primary and secondary levels significantly raises the performance achieved by students. The same evidence was related by Nussbaum et. al. (1999) mainly in learning mathematics and reading. Other studies showed that educational games offer an environment in which learning is enhanced by stimulating tasks, and skills are developed as a result of playing the game (McFarlane, D. C. and Latorella, K. A., 2002). Despite these advantages Hinostroza and Mellar (2001) show that most current educational software does not offer significant educational situations, especially educational games for math, which emphasize repetitive arithmetic tasks, restricting the focus on resolving problems without introducing them to the context. Murray et. al. (1998) confirm this concept and show that it makes the system unattractive and disappointing and may result in an opposite effect. In other words, the emphasis on conceptual aspects in this context results in a low achievement by students, who find no circumstances to develop the skills expected from the use of software, or develop
them in the wrong way. In spite of this data, projects for the development of multimedia systems, in most cases, do not involve users in a systematic manner during the development process of these systems (Norman and Draper, 1986).

Typically, the emphasis has been given only to the technological aspects, the empirical knowledge of professors, the experience of successful projects, or to formal scientific research, all, without considering the end user during the design (Nielsen, 2000).

Thus, the aim of the research was to highlight the importance of the User-Centered Design (UCD) for developing an educational information system, based on a computer game. First pilot studies will be presented for the validation of this system.

2. User Centered Design (UCD) in Educational Games

According to Mandel (1997), one of the difficulties of producing good quality educational software seems to be linked to the fact that in the design process there is a significant difference between representations that designers, programmers and teachers have on the teaching and learning processes. Tchounikine (2002), show the problems with the majority of educational software seem to be the difficulty between the elements designers have at their disposal and the way in which educators specify their ideas. According to the author, interaction between programmers and educators is a problem due to the difficulty of sharing concepts in different areas.

To solve this problem, a set of techniques was developed in Scandinavia intended to manage design with multidisciplinary teams and potential users. The proposed approach named Participative Design (PD), emphasizes the importance of democracy in a work environment, improving work methods, design process efficiency (through users experience and comments), and supporting multidisciplinary teams. From this point of view, the use of PD has brought the following benefits:

i. The company could follow-up and evaluate the project;
ii. Researchers had a greater understanding and power over the elements, as problems were shared between the directly involved participants. With this interaction researchers could carry out their theoretical proposals;

iii. Greater possibility of satisfying the company’s objectives, as they directly took part in the system’s development;

iv. Possibility of mutual learning and improving work practices;

v. Greater efficiency and quality.

The involvement of potential users in the project could not be disregarded in any of the software development phases, even the initial ones, such as the concepts, software architecture and content development. The users’ cooperation during the whole design process provided the work group with the necessary information.

Besides the PD activities, the resulting system quality is improved due to a better understanding of the potential users’ accomplished work by combining their know-how in the design process (Braa, 1996). At present the involvement of potential users only appears in the final development stages of a product, making it impossible to produce meaningful changes. To this fact, we can still add temporal commitments or financial difficulties. Therefore, by associating the methodologies proposed by the User Centered Design (UCD), we are trying to minimize the distances between the user’s real needs and the technological and didactical contributions of educational software.

According to ISO 13407, the UCD is a move towards developing interactive systems with the purpose of developing usable products. This should be a multidisciplinary activity that combines human factors, knowledge and Ergonomic methodologies. Applying Ergonomics in the design of interactive systems improves efficacy and efficiency, improves conditions of use, and avoids possible adverse effects on health, safety and performance. According to Rieman (1996), the most important role of educational software goes beyond the promotion of learning. Therefore, it is not only a question of learning how TO DO something with an interface, but of learning how to deal with an interface to LEARN a new concept. In this context, educational
interfaces hinder the cognitive development of users, with an impact on the learning of certain concept areas (Vergnaud, 1997).

3. Ergoshow: Development Methodology and Results

Ergoshow was developed for children (8-14 years old) and deals with subjects related to ergonomics, safety and health aspects. We started by assuming that the consolidation of the teaching-learning process happens when a youngster understands the “reason of things”, as opposed to being confronted with an ensemble of “prescriptions”.

The Ergoshow project team was composed by ergonomists, designers and an architect and was developed in three phases:

a) System definition concept;

b) Preliminary and detailed development;

c) Final validation.

In this article and for the reader to better fit into the perspective of UCD applied in these studies, we will describe the methodologies and results for each one of the previous phases.

3.1. System definition concept

The Ergoshow project was born from a request of the Portuguese Ministry of Labor and Solidarity, related to the need of producing didactic resources to raise awareness of primary education school students of issues related to Ergonomics, Safety and Health at Work. These resources will be used by primary education teachers, and integrated in their usual teaching program.

The Ergoshow’s concept definition was developed in the following 2 steps:
• Reference situation analysis of the multimedia pedagogical resources related to Ergonomics, Safety and Health at Work;
• Brainstorming meetings between the project’s team and teachers.

These steps that will be described below.

3.1.1. Reference situation analysis of the multimedia pedagogical resources related to Ergonomics, Safety and Health at Work

The reference situation analysis allowed the team to know the contents and explore similar products using heuristics to evaluate the user interface design and the information architecture of the main multimedia resources (Table 1). This exploration was done by two Human Factors specialists in four computer programs developed to give information about safety and health for young people.

Table 1 – Subjects and main characteristics of five multimedia resources developed to disseminate the contents of safety and health at work for children.

<table>
<thead>
<tr>
<th>Software</th>
<th>Sponsors</th>
<th>Subjects</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>The future adventures of Kid Safety</td>
<td>U.S. Consumer Product Safety Commission</td>
<td>Platform of online games that involves issues such as safety and accident prevention. It uses simple games as quizzes, puzzles, trivia, hangman, crosswords and arcade games. This online system conveys best practices for the prevention of domestic and urban accidents only through the various types of games that seek to transfer information to the children, without requiring them to obtain previous knowledge for solving various challenges. This formula seeks to awaken the natural interest of children by making it necessary for them to obtain the information from other sources in order to solve problems and overcome the various challenges presented during the games. Based on this system, the Ergoshow team opted to involve the children in a game environment, after each software module.</td>
<td>By internet browser using Java (<a href="http://www.cpsc.gov/Children/Childrensafety/">www.cpsc.gov/Children/Childrensafety/</a>)</td>
</tr>
<tr>
<td>Safer Journey: International Pedestrian Safety Awareness</td>
<td>U.S. Department of Transportation</td>
<td>It transmits contents related to the best conduct while crossing roads and crosswalks. It guides the users through a “virtual tour” where the best procedures are taught using a game with questions and answers. Curiosities and other important aspects related to the theme are also transmitted.</td>
<td>By internet browser using Adobe Shockwave(^\text{©}) Flash (<a href="http://safety.fhwa.dot.gov/saferjourney/journey/index.htm">http://safety.fhwa.dot.gov/saferjourney/journey/index.htm</a>)</td>
</tr>
<tr>
<td>NJPIES - Interactive Lead Learning</td>
<td>NJPIES - New Jersey Poison Information and</td>
<td>Interactive website containing alerts to the dangers of playing in unsuitable environments. The website classifies the dangers into five groups: park, house,</td>
<td>By internet browser using Adobe</td>
</tr>
</tbody>
</table>
Center | Education System | market, doctor and construction sites. In each one of these groups and through a simple system that involves the presentation of balloons, warnings and explanations about the various dangers are presented. These balloons are operated putting the mouse cursor over one of the elements in each environment. The website presents a simple and easy to understand language for the children. This simplicity was added into the Ergoshow by the development team in order to change some theoretical contents from the technical literature in simple and understandable contents for children from 8 to 12 years old.

Napo | Via Storia Production TV and European Agency for Safety and Health at Work | Napo is an original idea that answers the need for high quality information products that go beyond national borders in search of different cultures, languages and practical needs of workers. Napo and his friends are lovable characters in fun stories with humor and a relaxed approach. The “safety with a smile” concept is Napo’s contribution for improving safety and health at work places. Napo’s videos do not have verbalizations so, in this way, they must transmit “good practice” lessons through the character’s mime and body language. This concept was incorporated into the Ergoshow where many of the contents were adapted to simple speech, easily understood even without verbalizations.

Smart Children | Terra Networks Brasil S.A. | It is a children's game that encourages them to put the major internal organs of the human body in a correct position. It is a dynamic game and this application seeks to interest children in the anatomy and physiology of the human body. Based on this online application, the Ergoshow incorporated several challenges that invite children to interact with many elements of the human body.

Shockwave® Flash (www.njpies.org/lead/)


3.1.2. Brainstorming meeting with the project’s team and teachers

In this step we develop a brainstorming meeting with the project’s team, the primary school teachers and a focus group with children. We involved teachers with the objective of integrating their knowledge about the characteristics of the intended users, the integration of the Ergoshow in the tasks that they will perform in the classroom and the characteristics of the environment in which the potential users will be using the system (particularly related with the hardware).

A brainstorming meeting was set up between the project’s team and two teachers, specialized in the area of safety and health at work. The objective of this meeting was defining the theoretical contents and ways of presenting the information.

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The main results of this meeting were:

- Considering that muscle-skeletal problems related to work are a major problem in the European space, the group decided to introduce two modules: one related to manual load handling and another one with seated work. These contents are also important in the life of the *children* who manipulate every day loads (e.g. backpack) and spend much time sitting in the classroom and at home in front of a computer.

- Taking into consideration the need of new strategies for motivating students to those contents, the group decided to format them into a multimedia game.

- To prevent users from jumping between game levels, they need to view all the information from each level before answering a questionnaire and receiving a password to enter the next module.

- The theoretical content of the game must be integrated with real examples experienced by users, as for example “what happens if I’m playing videogames for a long time?”

- The group decided to propose the development of a mascot using an animated skeleton metaphor.

- Related to the language the group decided to use a mixed between formal language with theoretical contents and some breaks with jokes to keep the younger’s attention.

- Regarding language the group decided to use a mix between formal language with theoretical contents and some breaks with jokes to retain the youngster’s attention.

- In order to allow accessibility of deaf *children*, the group also decided to reserve an area where all the verbalizations were written.

- The minimum characteristics of the hardware to play the game are a Pentium II with 200Hz, 256Mb RAM, graphics 8Mb, 1GB HD free and Windows 98.

Regarding to these results, it is important to emphasize that the contents of the multimedia support came from the UCD methodology and expresses the needs of the potential users, children (students) and teachers (which need this kind of didactic materials to improve their work).
3.2. Preliminary and detailed Development

The preliminary and detailed development was aimed at developing the previous concept. In a first step, the team’s group developed solutions for these concepts, then the teachers and younger’s were involved in focus group meetings, to give feedbacks and suggestions about them.

A focus group meeting was set up between the project’s team and three teachers, specialized in the area of safety and health at work. The objective of this meeting was to receive feedback and suggestions about the theoretical contents and the first prototype of the mascot.

Table 2 shows the main results related to the theoretical contents’ hierarchy. It is divided into 3 modules, each one with 3 levels.

Table 2 – Hierarchy of the theoretical contents.

<table>
<thead>
<tr>
<th>Module I – Manual Handling of Loads</th>
<th>Level</th>
<th>Knowledge</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>Understands recommendations on lifting, carrying loads.</td>
<td>Caution before lifting a load. Postural procedures to lift a load. Postural procedures to carry a load. Care to place a load.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Understands and simulates the effect of forces applied on the Spine and consequences of this action</td>
<td>Axial and cutting forces and flexor moments. The effect of these forces on the vertebral structures. The effect of posture on the intensity of the forces acting on the spine. The effect of external loads in the intensity of the forces acting on the spine.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module II – Seated Work</th>
<th>Level</th>
<th>Knowledge</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>Explains how muscles function.</td>
<td>Static and dynamic muscular work. Mechanism of muscle contraction. Factors that explain muscle fatigue.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Includes recommendations on placing chairs, tables and footrests according to the anthropometric dimensions of users.</td>
<td>Strategies of the sitting posture. Adjusting a chair (seat height, backrest, armrest) according to anthropometric dimensions Interaction with the desk. Characteristics of a desk.</td>
</tr>
</tbody>
</table>
Related to the mascot designer, we developed a prototype using a metaphor of a funny skeleton was called BONE (Fig 1). BONE is the host in all the software’s stages and phases. It is an adolescent skeleton, was designed in live colors, with a *hip-hop* appearance, cartoon characterization and uses adolescent language.

--- ENTER FIGURE 1 ABOUT HERE --------------------------

Figure 1 – *The evolution concept of the mascot – BONE, select by focus group and interviews with real users.* (A) Anatomy concepts; (B) Cartoon characterization and (C) *Hip Hop and Street costume.*

Some teachers expressed doubts about the use of a skeleton, symbolizing death, to expose contents on health and safety. On this subject, it was decided to ask for the children opinions that will be presented below.

### 3.2.1. Focus group meetings with the children results

Three focus group meetings with a young people sample using a paper and digital prototypes were conducted in order to check their feelings, opinions and suggestions about:

- BONE mascot;
- Ergoshow's storyboard and;
- Identifying interaction problems in the first functional prototype.
About the BONE mascot, the reactions to the skeleton figure (BONE) were very good. Here are some opinions expressed by the 20 children:

- It is a beautiful boy. Can I interact with it?
- The mascot is good, but it will be better with other colors.
- It is a good-looking skeleton. Can I have some images?
- The figure is attractive, what is its name?

According to the children comments and suggestions we changed the mascot’s colors and dress accessories.

In order to evaluate the adaptation of the contents, the Ergoshow’s Storyboard was assessed through a focus group with 10 students. The obtained main results were related with a better explanation of some concepts, in a language closer to the one used by young people.

Figure 2 illustrates the storyboard used for evaluating the game’s implementation of a text developed for demonstrating how to manipulate loads.

------------ ENTER FIGURE 2 ABOUT HERE ---------------------

Figure 2 – Storyboard used to evaluate the game implementation of a text.

Based on these suggestions we carried out a brainstorming meeting with the team, to develop a methodology for using language closer to the potential users. The main result of this meeting was the need to listen to young people during their daily activities and adapting the explanation of concepts, with the introduction of a language that they normally use.

In order to evaluate the interaction problems and give potential solutions to improve the computer game, we used observation and “think aloud” methods. A sample of 10 students interacted with the program (Figure 3) to perform a task related with
vertebral column functioning and at the end answered five multiple-choice questions. We measured the errors made during the interaction, the performance with the questions and the "think aloud" comments while they interacted with the program.

Figure 3 – Some frames of the Ergoshow program used in the usability test to evaluate interaction problems.

All participants were informed that the goal was testing the program, not the participant’s performance so they should be honest in their comments. The results of this test were very positive and we developed a simple and clean user interface that would cause no problems to children. Another positive aspect was that the children showed they would like to have the final version of the program, repeatedly asking where they could purchase it. These results motivate the team to continue this project using the same described methodologies and strategies.

3. 3. Interface Description

For a better understanding of the user interface, we will describe the main aspects of the interface. The items were grouped in one of the following 4 functional areas (Figure 4):

a) **Top Toolbar:** On this toolbar we can find the software’s control elements, as well as the system user’s situation and reference indicators.

b) **Host Area:** On the left side there is an area set apart for the host. In this area the mascot performs several movements without interfering with the Animation Table’s elements.

c) **Animation Table:** This area is characterized by a white board, in which animations described by “BONE” are posted and where all the animations, films
and also questionnaires appear. On the top of the animation table we can always see a text about the subject being viewed.

d) **Lower Toolbar**: Directly below the animation Table is a bar designed exclusively for subtitling. The prime objective of this area was to make the contents accessible to hearing impaired people, thus broadening the number of possible users of this program.

Figure 4 - Layout items 1- program name; 2 - module indicator showing where the user is; 3 – indicator of the level at which the user is; 4 – indicator of the score obtained by the player; 5 – help button, return to previous page and leave the program; 6 – area reserved for locution subtitling; A – top toolbar B – animation table; C – host’s area D – lower toolbar.

### 3.4. Final validation

The validation of the first prototype was developed to explore the aspects of a multimedia game’s interface (sound, graphics, interaction, technical language, everyday language and the possibility for reviewing), most appreciated by children (Rebelo, F. et al. 2007). In this part of the study we used a sample of 36 students from two 4th grade classes, 19 male and 17 female students, divided in 4 groups (3 groups of 10 students and one group of 6 with one computer for each student).

Regarding the test results, the Friedman Analysis of Variance for repetitive measures, shows that the importance is not identical for the six interface components. This means that the students award different degrees of importance to each one of the studied groups (sound, graphics, interaction, technical language, every day language and the possibility for reviewing).
To explore which one of the groups is more important for the proposed activities, we applied a multiple comparisons test and we verified that for the Ergoshow “module I – Load Transportation”, significant differences between:

- sound and graphics;
- graphics and the possibility for reviewing;
- interaction and the possibility for reviewing;
- technical language and the possibility for reviewing;
- every day language and the possibility for reviewing.

When observing the ranks’ means corresponding to each one of the groups we conclude that the possibility for reviewing is the group that obtained the most significant value.

Regarding the Ergoshow game’s “Module II, Seated Work”, we verify significant differences between:

- sound and technical language;
- technical language and the possibility for reviewing;
- every day language and the possibility for reviewing.

When observing the ranks’ means corresponding to each one of these groups we concluded that the possibility for reviewing is, also in this module, the group that obtained the highest score regarding technical language and everyday language.

4. Analysis

The work presented in this article had the merit of involving potential users during the whole development process of an information system. We contextualized this methodology in the design of an educational software ensemble, in game format, for adolescents from 8 to 14 years old.
The potential users’ involvement in the various development phases of this information system allowed for:

- Answering doubts about the use of a skeleton mascot and improved it according to the needs and potential expectations of users.
- Improving the game format and the level of difficulty of the questions;
- Verifying if the examples complied with the future users’ everyday realities;
- Identifying and changing small problems of the first graphic and navigational environment proposal;
- Evaluating the used language, introducing some expressions used by adolescents, without damaging the transmitted information’s thoroughness.

In Synthesis:

- A better adjustment of the Ergoshow to the users’ mental model, their needs and expectations.
- The possibility to identify mistakes that would be difficult to correct at the end of the project.
- Reducing expenses, as corrections at the end of the project would mean added costs.

Regarding the use of Participative Design, we became aware that applying these kind of techniques and others, originating from organizational psychology and management areas, are extremely important for managing the development of educational products, for controlling each one of the development stages and reinforcing individual competencies of each one of the involved persons.

The UCD has brought enormous benefits to the project. Only by frequent enquiries in each of the product’s development phases, is it possible to adjust, in the best possible way, what designers think of the project regarding imagination and expectations of the target population. Mainly because imagination varies according to Mauss (1990), regarding the:

- Culture of the analyzed people;
• Age group of the target population;
• And gender.

It was surprising to observe that the system attracted the attention of individuals outside the proposed age group, mainly adults, with different kinds of profiles and cultural levels. Therefore, this product generated the interest of some companies that requested it for training their staff in the area of Safety and Health at Work.

Information technologies have been used in school environments for over twenty years, with most of its development taking place in the eighties, when personal computers emerged (Hinostroza and Mellar, 2001). An important reason that justifies applying information technologies in this environment is the capacity to improve student’s learning, by giving the student an opportunity to develop different kinds of competencies.

5. Discussion

Despite this we recognize that the application of the UCD method could restrict all the potentialities of ergonomics and fields of intervention and we think that the final work was closer to the needs and expectations of the children. Being aware of this problem and all along the presentation of the Ergoshow subjects, we highlight the importance of ergonomics in the other fields of intervention.

Compared to methods that do not take into account the overall involvement of the potential users in the early stages and the definition of concepts, this study showed many advantages by using UCD procedures in the development of tools for education. This approach allowed us to avoid the academic tendency to set concepts and theories based on our need of making the importance of ergonomics and its fields of intervention known. Apart from the content, the implementation of the UCD methodology allowed us to find the most attractive format for children to be exposed to ergonomic contents in an easier way. The format of a game with the specificity referred by potential users, confirmed many of the observations of other authors and
without them we would naturally be led to consider the exposure of the contents in a less attractive way, with the possible consequences for motivating children (Nussbaum et. al. (1999); Hinostroza and Mellar (2001); McFarlane, D. C. and Latorella, K. A. (2002).

The results obtained with potential users were satisfactory regarding performance, motivation and learning expressed by the children. This fact can be confirmed by the insistence of many children (who participated in the meetings and in the evaluation of the project's different phases) of knowing how their parents could buy a full version of Ergoshow.

These results lead us to believe that this process, in spite of demanding more time and financial resources in the development process, will meet the needs and expectations of potential users more easily.

In conclusion, this project proves that it is a welcome tool for transmitting information about ergonomics and occupational safety and health.

References


**Acknowledgements:** We wish to acknowledge the support of the Occupational Health Institute (ISHST), the National Educational Programme for Occupational Health (PNEST) and all the students who cooperated in this study.
Figure 1 - The evolution concept of the mascot – BONE, select by focus group and interviews with real users. (A) Anatomy concepts; (B) Cartoon characterization and (C) Hip Hop and Street costume. (317,5 x 177,2 mm)

Figure 2 – Storyboard used to evaluate the game implementation of a text. (189,5 x 117,3 mm)
Figure 3 – Some frames of the Ergoshow program used in the usability test to evaluate interaction problems. (323,1 x 104,8 mm)

Figure 4 - layout items 1- program name; 2 - module indicator showing where the user is; 3 – indicator of the level at which the user is; 4 – indicator of the score obtained by the player; 5 – help button, return to previous page and leave the program; 6 – area reserved for locution subtitling; A – top toolbar B – animation table; C – host’s area D – lower toolbar. (183,4 x 147,8 mm)